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Editors: Anne Morton, Gary Presland, Maria Gibson

Editorial Assistant: Virgil Hubregtse

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From the Editors

It has long been recognised, and occasionally commented on, that *The Victorian Naturalist* is the longest continuously published scientific journal in Victoria. This is something of which the Field Naturalists Club of Victoria can be proud. Through 127 years of production, the range of subject matter published has been extensive, comprising one of the significant elements of this journal. Indeed, the current issue is a good example of this aspect of *The Victorian Naturalist*. Here readers will find Research Reports on flora, fauna and resource management; Contributions on processes of environmental change and protection of frog species; and Naturalists Notes that focus on diverse aspects of ecology.

Front cover: *Dermocybe clelandii*. Photo by Pat Grey. See page 205.

Back cover: Southern Brown Tree Frog *Litoria ewingii*. Photo by Robin Drury. See page 201.

Long-term changes in the flora and avifauna of Rabbit Island, Wilsons Promontory, Victoria

FI Norman¹, P Dann^{2,6}, TL Montague³, S Unthank⁴
and R Thoday⁵

¹Lot 11 Cullen Crescent, Plenty, Victoria 3090

²Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Victoria 3922

³Department of Mathematics and Statistics, The University of Melbourne, Parkville, Victoria 3052

⁴133 Graydens Road, Tuerong, Victoria 3915

⁵Deceased

⁶Corresponding author

Abstract

Removal of European Rabbit *Oryctolagus cuniculus* from Rabbit Island, Wilsons Promontory, Victoria, by 1968 resulted in increased vegetation, including an expanded shrubland, and was associated with increased Short-tailed Shearwater *Ardenna tenuirostris* and Little Penguin *Eudyptula minor* populations. Seabirds and vegetation were described in 1959, and since 1965 vegetation changes and birds present were noted on numerous visits. In one series of observations between 1965 and 1988, 13 non-passerine and 11 passerine species were reported. In another series made between 1986 and 1988, two other passerines and six additional non-passerines were seen; a further seven passerines and an additional 15 non-passerines (mostly in small numbers, often flying over the island) were recorded between 1991 and 2002. Raptor species were frequently seen, but some sightings of non-passerines (usually seen flying over or off the island) and most passerines were infrequent. Most birds recorded were dispersive, nomadic or migratory. Plant species also increased, from 24 (including four alien species) reported in 1959 to some 70 (including 14 alien species) found in recent visits. Nevertheless, changes in the island's simple floristics have not resulted in any substantial increase in species of breeding birds. (*The Victorian Naturalist* 127 (5) 2010, 160–167).

Keywords: Rabbit Island, rabbit eradication, birds, plants, changes

Introduction

Rabbit Island, some 2 km off the north-eastern coast of Wilsons Promontory, Victoria, is a small (c. 32.4 ha), domed granite island rising to about 60 m above sea level (Fig. 1). In 1959, the island had a 'sand-filled valley' inland above the beach (Gillham 1961), an eroded area which occupied some 6.5 ha in 1965 (Norman 1967, 1970). European Rabbit *Oryctolagus cuniculus* carcasses were numerous at that time, presumably reflecting a recent outbreak of myxomatosis. Subsequent baiting with '1080' (sodium fluoroacetate) removed the remaining individuals. Following this eradication, vegetation cover increased and the eroded area gradually disappeared, becoming colonised mainly by *Senecio lautus* and *Poa poiformis* among which various shrub species later became established (e.g. Norman 1970; Norman and Harris 1981; Norman 1988). Norman and Harris summarised aspects of vegetational changes on Rabbit Island between 1959 and 1979. In brief, they commented on the extensive changes along and above the sand beach region where some

species (e.g. *Rhagodia candolleana* syn. *bacata*) had increased in cover while others (e.g. *Cakile maritima*) declined; further changes in structure and vegetation were noted in March 1988 (Norman 1988). By 1979 the eroded area finally had disappeared and shrubs (*Leptospermum laevigatum*, *Acacia longifolia* and *Leucopogon parviflorus*) were extensive; indeed the shrubland extended from above the beach and across the island towards the summit in 1988. The number of vascular species recorded on the island in 1959 (24, including four alien species, Gillham 1961) had substantially increased by 1979 to 63, including 14 aliens (Norman and Harris 1981). A *Festuca* sp. was found in 1988 (Norman 1988). In the same period, breeding areas used by the Short-tailed Shearwater (for scientific names of birds see Table 1) expanded and bird species recorded on the island also increased, though representation was usually by sightings of single, 'transitory' individuals (Norman and Harris 1981).



Fig. 1. Oblique view of Rabbit Island, Wilsons Promontory, Victoria, September 2008 (courtesy of Nicole Schumann).

Unusually for most Bass Strait islands, there has been an extended series of visits to Rabbit Island since 1959. The island now has been without rabbits for over 40 years, and without fire for more than 50 years (Gillham 1961). This note presents a summary of observations on the island's flora and avifauna made between 1985 and 2002, and provides a brief comparison with material presented in previous studies.

Methods

Considered here are records obtained: (i) in 1959 (e.g. Gillham 1961) and then by FI Norman (FIN) during irregular, mainly daylong, visits; nine between May 1965 and September 1968; others in 1978 and 1979 (see Norman and Harris 1981); (ii) between December 1985 and March 1988 by TL Montague (TLM) during regular (monthly) visits which lasted 3 days, when specific details for species other than Little Penguins were recorded during 20 visits from April 1986 onwards; (iii) during a three-day visit by FIN in March 1988 (see Norman 1988); and (iv) by the Penguin Study Group (PSG) of the Victorian Ornithological Research Group between February 1991 and January

2002. These were annual visits which lasted 1-3 days (see PSG reports, in references).

During visits between July 1987 and February 1988, trapping for mammals was undertaken on a grid established in *Acacia longifolia* and *Poa poiformis* just above the western sand beach, using 28 baited Elliot traps (TLM). Another trapping session was conducted between 27 October and 1 November 1995 (Dzedins 1995). Skinks were occasionally caught by hand.

Results

Flora

Vegetation changes – species

By 1988, some 63 (including 13 alien) species of vascular plants had been recorded at Rabbit Island (Norman 1988). However, the PSG recorded some 14 or 15 plant species during their 1991 visit (Thoday 1991), adding three (*Myoporum insulare*, *Alyxia buxifolia* and *Sambucus gaudichaudiana*) to those previously recorded (although Gillham (1961) had previously recorded a *Sambucus* sp.). A more extended plant list compiled by PSG during the 1993 visit included 29 species, of which *Dicksonia antarctica*, *Coprosma repens*, an alien species that was

removed in 1997 (Thoday 1998), *Dichondra repens*, *Calystegia soldanella* and (perhaps) *Urtica incisa* were additional island species (Thoday 1995a). No new species were reported by Alison Oates (unpubl. data) in a list of some 15 species obtained during a visit in 1995, but the PSG added *Dichelachne crinata* in 1998 (Thoday 1999). In total, at least 70 vascular species have been recorded from the island, including 14 alien species.

Vegetation changes – general

By 1988, the vegetation of Rabbit Island was dominated by extensive tussock grassland *P. poiformis* communities, particularly at the northern and southern ends, and shrubland (dominated by *Acacia longifolia*) extended from the beach towards the island summit (Norman 1988). At this time (and as recorded earlier), the beach area generally was covered by the salt-bushes *Atriplex* and *Rhagodia*, although other species dominated some parts; cover by woody species in the eroded area had increased at the expense of *P. poiformis* (Norman 1988).

The PSG (Thoday 1991) indicated that shrubland extended from above the beach, across the summit, to the eastern coast. The tussock grassland then covered the remainder of the island although other plant species were 'sparsely scattered' elsewhere. Thistles (presumably *Carduus* sp.), which had been dry in 1991, were 'thick' behind the beach and isolated 'patches' occurred elsewhere (Thoday 1994); they were not apparent in 1994 when *Poa* growth was reduced (Thoday 1995b). Dzedins (1995) noted that *P. poiformis* dominated the island when visited in 1995, a time when there were extensive areas of *Rhagodia candolleana*, *Tetragonia tetragonoides* and patches of *Acacia sophorae*, *Myoporum insulare* and *Leptospermum laevigatum*. Dry conditions also affected the tussock grass (and some *Rhagodia*) in 2001, although the wattle *Acacia sophorae* was apparently 'thriving' (Unthank 2001). In 2002, shrubs had spread to form two 'large' areas, and the thistle (*Carduus tenuifloris*) was 'plentiful', whereas *Solanum laciniatum* had substantially declined (Unthank 2004). The tussock grassland and shrubland cover in September 2008 is indicated for the western side of the island in Fig. 1.

The mobility of the beach area was noted during many visits (e.g. Norman 1988; Thoday 1995a, 1995b), with substantial structural and floristic changes occurring between them.

For example, in 1988 the embryo dune had disappeared and the secondary dune was undercut, with *Cakile maritima* disappearing to be replaced by *Atriplex hastata* and *Rhagodia candolleana* (Norman 1988). Similarly, the PSG indicated that the beach was being eroded in February 1991 (Thoday 1991); it had disappeared in 1994 (Thoday 1995b) but was partially regenerated by 1998 (Thoday 1998).

Bird species

Little Penguin *Eudyptula minor*

Gillham (1961) considered that there were 'many hundreds' of burrows in 1959 and up to 500 were estimated in 1979 (Norman *et al.* 1980b; Norman and Harris 1981). This was considered an underestimate (Norman 1988) and visits between 1985 and 1988, when most Little Penguin nests were on the western side of the island, above and at each end of the sand beach (although droppings and occasional occupied nests were found elsewhere), suggested a burrow total of around 2500. By 1991 some 4000 burrows were estimated (Thoday 1991) although totals in 1995 and 1996 were considered much lower (Thoday 1995c, 1997). No later estimates are available.

Short-tailed Shearwater *Ardenna tenuirostris*

In 1959 there were 'many thousands' of burrows (Gillham 1961), and Harris and Norman (1981) estimated a total of around 131 000 (see also Norman *et al.* 1980b). While Gillham (1962) noted that there were few burrows in the sand-filled valley (i.e. the eroded area), with birds being unable to maintain them, by 1968 a part of this area had been colonised, a process which was well-advanced in 1978 (Norman and Harris 1981; Norman 1988). In the 1985–1988 period, Short-tailed Shearwaters nested across the island, wherever burrows could be formed, although few were found beneath *Acacia*, perhaps a consequence of difficult access and the tendency of associated soils to collapse. During visits by the PSG, a maximum of 210 000 burrows were estimated (Thoday 1991), but some declines were noted (e.g. in 1994, Thoday 1995b).

Cape Barren Goose *Cereopsis novaehollandiae* Neither Gillham (1961) nor Dorward (1967) reported any Cape Barren Geese on Rabbit Island and they were similarly absent from 1965 to 1968 (Norman and Harris 1981). Geese were

Table 1. Bird species recorded at Rabbit Island, Wilsons Promontory, Victoria (maxima and/or comment). (Sequence, and common and scientific names follow Christidis and Boles 2008). Details from: ¹ Norman and Harris (1981); ² Norman (1988); ³ TLM unpublished; ⁴ PSG reports by Ron Thoday and Spencer Unthank. * = breeding recorded; o/h = overhead; √ = present; x = alien.

Species	1965-1979 ¹	1988 ²	1985-1988 ³	1991-2002 ⁴
Cape Barron Goose* <i>Cereopsis novaehollandiae</i>	18 (incl juveniles)		12 pairs	26 (including young)
Black Swan <i>Cygnus atratus</i>				4 (o/h)
White-throated Needletail <i>Hirundapus caudacutus</i>				2 (o/h)
Short-tailed Shearwater* <i>Ardenna tenuirostris</i>	see text	see text	see text	see text
Common Diving-Petrel <i>Pelecanoides urinatrix</i>				1 found dead
Little Penguin* <i>Eudyptula minor</i>	see text	see text	see text	see text
Australasian Gannet <i>Morus serrator</i>			√ (offshore)	11 (offshore)
Little Pied Cormorant <i>Microcarbo melanoleucos</i>			√	3
Great Cormorant <i>Phalacrocorax carbo</i>				3
Little Black Cormorant <i>Phalacrocorax sulcirostris</i>			√	3
Black-faced Cormorant <i>Phalacrocorax fuscescens</i>	√			124
Eastern Great Egret <i>Ardea modesta</i>				1 (o/h)
White-faced Heron <i>Egretta novaehollandiae</i>	√		√	2
Australian White Ibis <i>Threskiornis molucca</i>				7 (o/h)
White-bellied Sea-Eagle <i>Haliaeetus leucogaster</i>			√	3 (o/h)
Whistling Kite <i>Haliastur spheurnus</i>	√			1
Swamp Harrier <i>Circus approximans</i>	√		√	3
Wedge-tailed Eagle <i>Aquila audax</i>				2 (o/h)
Nankeen Kestrel <i>Falco cenchroides</i>	√			1 (o/h)
Brown Falcon <i>Falco berigora</i>	√		√	1 (o/h)
Peregrine Falcon* <i>Falco peregrinus</i>	√	2	√	4
Australian Pied Oystercatcher <i>Haematopus longirostris</i>				2
Sooty Oystercatcher* <i>Haematopus fuliginosus</i>	3 nests		√*	12+
Latham's Snipe <i>Gallinago hardwickii</i>				1
Bar-tailed Godwit <i>Limosa lapponica</i>				1
Caspian Tern <i>Hydroprogne caspia</i>				1
Crested Tern* <i>Thalasseus bergii</i>			√*	220
Pacific Gull* <i>Larus pacificus</i>	5 nests		√	52
Kelp Gull <i>Larus dominicanus</i>			√	
Silver Gull* <i>Chroicocephalus novaehollandiae</i>	27 nests		√*	20
Yellow-tailed Black-Cockatoo <i>Calyptorhynchus funereus</i>				7 (o/h)
Sulphur-crested Cockatoo <i>Cacatua galerita</i>				1 (o/h)
Blue-winged Parrot <i>Neophema chrysostoma</i>				1
Pallid Cuckoo <i>Cacomantis pallidus</i>				1
Superb Fairy-wren <i>Mahurus cyaneus</i>	√			
Yellow-faced Honeyeater <i>Lichenostomus chrysops</i>				2
White-eared Honeyeater <i>Lichenostomus leucotis</i>				1
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>				1
Olive Whistler <i>Pachycephala olivacea</i>				1
Australian Magpie <i>Cracticus tibicen</i>	√			
Grey Fantail <i>Rhipidura albiscapa</i>			√	2
Forest Raven* <i>Corvus tasmanicus</i>	?	41	√	75
Satin Flycatcher <i>Myiagra cyanoleuca</i>				1
Flame Robin <i>Petroica phoenicea</i>			√	
*Eurasian Skylark <i>Alauda arvensis</i>	√		√	
Little Grassbird <i>Megahurys gramineus</i>				3
Silvereye <i>Zosterops lateralis</i>	√	20+	√	20
Welcome Swallow* <i>Hirundo neoxena</i>	√		√	9
Fairy Martin <i>Petrochelidon ariel</i>	√			
Tree Martin <i>Petrochelidon nigricans</i>				2 (o/h)
*Common Blackbird <i>Turdus merula</i>	√			2
*Common Starling <i>Sturnus vulgaris</i>	√			
Australasian Pipit <i>Anthus novaeseelandiae</i>	√			
*European Goldfinch <i>Carduelis carduelis</i>	√			1

Table 2+. Species:area ratios for vascular plants found on some Wilsons Promontory islands, listed in the order of increasing exposure as estimated by Gillham (1961).

Island	Total		Proportion of native species (%)	Ranking by native proportion	Area (ha)	Species:Area Ratios		Adjusted ranking (ratio for native species)
	Vascular species	Native species				All species	Native species	
Granite ¹	22	15	68.2	7	1.1	20.9:1	14.2:1	1
Rabbit ²	70	56	80.0	6	32.4	2.2:1	1.7:1	4
Cliffy ¹	41	23	56.1	8	7.7	5.3:1	3.0:1	2
McHugh ⁴	18	18	100.0	1	9.2	1.9:1	1.9:1	3
Dannevig ⁵	25	23	92.0	3	19.6	1.3:1	1.2:1	5
Citadel ⁶	25	21	84.0	5	18.8	1.3:1	1.1:1	6
Wattle ⁷	27	24	88.9	4	21.4	1.3:1	1.1:1	6
Norman ⁷	27	26	96.3	2	48.0	0.6:1	0.5:1	7

¹ Gillham (1961) and unpublished data. ² Gillham (1961), Norman (1970, 1988), this study. ³ Hope and Thomson (1971). ⁴ Gillham (1961) and unpublished data. ⁵ Gillham (1961), Norman *et al.* (1980a). ⁶ Norman and Brown (1979). ⁷ Norman *et al.* (1980a).

first recorded, and breeding, on the island in 1978 (8 adults and 2 young) and 18 (including 2 or more juveniles) were seen in 1979 (Norman *et al.* 1980b; Norman and Harris 1981). Numbers of geese varied considerably (1–30) between 1985 and 1988, with apparent peaks in August when egg-laying was at a maximum. Nests were found under the *Acacia* shrubs near the summit and on the western slopes, and up to 12 pairs bred. The PSG recorded geese on every visit, and up to 26 (including young) were seen in 1992 (Thoday 1994).

Other bird species

In 1959, only seabirds present (or breeding) on Rabbit Island were reported (e.g. Gillham 1961), but Norman and Harris (1981) provided a listing of 24 species (including an unidentified corvid) for the island (see Table 1). The PSG found a carcass of a diving-petrel, presumably *Pelecanoides urinatrix* (Unthank 2001), although to date no nests have been found. Other seabirds have been seen roosting on rocks (e.g. some 124 Black-faced Cormorants *Phalacrocorax fuscescens* seen in 1994; Thoday 1995b) or offshore. Three nests of Sooty Oystercatchers *Haematopus fuliginosus* were found in 1978–1979 (Norman *et al.* 1980b), breeding was recorded in 1986–1988 and in the 1991–2002 period, nests were found during most visits, with a maximum of nine nests in 1999 (Thoday 2001). Silver Gulls *Chroicocephalus novaehollandiae* were recorded as a breeding

species in 1979. There were 27 nests, and some 100 pairs (Norman and Harris 1981). Breeding was also observed in 1986–1988 and late 1995. Crested Terns *Thalasseus bergii* were first seen nesting on the island in 1986–1988 on the western coast, about 100 m north of the beach, just in front of areas where *P. poiformis* reached the exposed granite. In 1999, some 220 terns were seen, but no breeding was observed (Thoday 2001). No breeding Pacific Gulls *Larus pacificus* were seen in 1959, but five nests were found in 1979 (Norman *et al.* 1980b). However, while no breeding was observed between 1986 and 1988, the PSG found up to 16 nests in the 1991–2002 period (although juvenile Pacific, and Kelp *Larus dominicanus*, Gulls were seen between 1986 and 1988). Other non-passerines (Table 1) were seen flying over, e.g. Black Swans *Cygnus atratus* (Thoday 1991) and Sulphur-crested Cockatoo *Cacatua galerita* (Thoday 1995a), or occasionally on, the island, e.g. one Bar-tailed Godwit *Limosa lapponica* (Thoday 1995a) and one Latham's Snipe *Gallinago hardwickii* (Thoday 1995c).

In the review period, species of birds of prey recorded have increased. While Peregrine Falcons *Falco peregrinus* were observed from 1965 onwards (and assumed to breed in the eastern cliffs), they were present on 12 of 20 visits between 1986 and 1988, and one to four birds were seen during seven of eleven visits between 1991 and 2002. Swamp Harriers *Circus approximans* (maximum eleven), Brown Falcons *Falco ber-*

igora and White-bellied Sea-Eagles *Haliaeetus leucogaster* were regular visitors, but Wedge-tailed Eagles *Aquila audax* were less frequently seen over the island.

Despite regular visits between 1986 and 1988, relatively few passerine species were seen on a regular basis, but Grey Fantail *Rhipidura albiscapa* and Flame Robin *Petroica phoenicea* were added to the island list in this period. PSG visits added another seven passerine species, including honeyeaters (Table 1). Welcome Swallow *Hirundo neoxena* nests were reported on several PSG visits. The Forest Raven *Corvus tasmanicus* appears to have bred only occasionally (Thoday 1991), although the species regularly visits the island (75 seen in 1991).

Skinks and mammals

When visited in December 1978, a 'lizard' and 'rat' were seen (MP Harris pers. comm.); somewhat later (1985–1988) TLM recorded an extensive population of Swamp Antechinus *Antechinus minimus*, and found that the Water Skink *Eulamprus tympanum* was widespread. However, while Dzedins (1995) reported *Egernia whitii* (as well as commenting on *A. minimus*), Thoday (2001) noted the apparent confusion relating to the identity of the skink species and favoured *E. tympanum*.

Discussion

When Gillham (1960, 1961, 1962) reviewed the floristics of some Promontory islands (including Rabbit Island) she visited in 1959, she developed a ranking which showed that plant species per unit area decreased with increasing 'exposure', and noted that species totals were depressed by seabird activities, rabbit grazing, reduced soil depth and salt spray. To some extent, the indices improved when only native species were considered (e.g. Hope and Thomson 1971). Vegetation details for some islands visited previously by Gillham have improved, for example, Citadel Island (Norman and Brown 1979, Dannevig Island (Norman *et al.* 1980a), and Rabbit Island (summarised here) where visits have been extensive since 1959. Thus by 1998, some 70 vascular species (including 14 aliens) had been recorded there, a substantial increase when compared with the list of 24 (4) provided by Gillham (1961), a list which resulted in a species:area ratio of 0.7:1 in 1959 (using an island area of 32.4 ha; Norman 1970). Gillham (1961) felt that rabbits had depressed totals

recorded. Later collections that followed rabbit removal showed an increase in the species total, by at least 46 (10) species, and hence raised the ratio for all species per unit area to 1:0.5, as reported by Norman *et al.* (1980a). To some extent then, removal of rabbits and the continued absence of fires have been followed by an increase in the island's flora, as has also occurred on Citadel Island (Norman and Brown 1979), hence supporting Gillham's views. Nevertheless, revision of plant lists for selected Promontory islands (Table 2) suggests that Cliff Island (with a large proportion of alien species, and the lowest native species:area ratio) is perhaps, paradoxically, less 'exposed' than other islands. Indeed Norman Island, the largest of the islands considered here, would now appear to have the lowest ratio and, following Gillham, is probably the most influenced by exposure. Further, it should be noted that 'new' plant records may be of isolated (perhaps temporary) individuals rather than well-established communities.

The influence of human activities has been considered in previous discussions on the vegetation of Promontory and Bass Strait islands. Thus the modification of the floristics in the Hogan Group (Hogan, Long and East Islands) was seen as a consequence of frequent burning and grazing by cattle; some 40% of plants found on Hogan Island itself were alien species, introduced by or with stock (Scarlett *et al.* 1974). At Cliff Island, where a lighthouse was established in 1884, a similar proportion of alien herbs has been recorded (Hope and Thomson 1971). Increased alien content also has been noted for other local islands where occupation, cutting and burning of shrub species has occurred; other islands with a low alien content (see Table 2) may reflect an absence of human disturbance (e.g. Norman *et al.* 1980a; Norman 1988). Further, the role of frugivorous bird species in the spread of some plant species (both alien and native) should not be ignored.

During Gillham's 1959 visit to Rabbit Island, observations were made only on seabirds present (e.g. Gillham 1961). In nine later visits between 1965 and 1968 (Norman 1970), in late 1978 and 1979 (three visits, Norman and Harris 1981) and March 1988 (Norman 1988) other bird species, including passerines, were recorded and the island's bird list had reached some 24 species (13 non-passerines; 11 passerines including the unidentified corvid—

presumably the Forest Raven; see Table 1) by that time. Observations made on regular visits between early 1986 and early 1988 added two passerines (Grey Fantail and Flame Robin) and six non-passerines (including birds seen on, over or around the island), one (Crested Tern) recorded breeding apparently for the first time. The visits by the PSG between 1991 and 2002 added a further seven passerines and 15 non-passerines (including several flying over the island), with the result that 54 species (34 non-passerines and 20 passerines) have now been recorded. Of the non-passerines, raptors were well-represented (several being reported frequently) as was a range of shorebirds (though these were often seen only once). As noted previously (e.g. Norman and Harris 1981; Norman 1988), few of the passerine species inhabit the island regularly or indeed breed there, with most being single sightings of transitory individuals rather than resident species; more recent observations tend to support this view. Indeed, few if any of the passerines are regularly observed and, of the 20 passerines recorded (Table 1), most are considered to show dispersive, migratory, or nomadic movements (Garnett *et al.* 1991, Pizzey and Knight 2007) and only the raven has been reported to breed on the island. To some considerable extent, the small numbers of breeding species reflects the island's simple floristics and vegetation structure, and the reduced shrub cover. Indeed, on an unidentified 300 ha island elsewhere in Bass Strait, where sheep and deer have been eliminated and revegetation has been substantial, a range of birds now occurs, including honeyeaters and other migrants (Johns 2008). In this regard, Abbott (1973) noted that smaller Bass Strait islands had a depauperate avifauna as a result of reduced immigration and invasion rates, and an absence of *Eucalyptus* species; removal of scrub, grazing and burning must also play local roles.

As the number of bird species recorded on and around Rabbit Island has increased, so too have populations of several species also grown. Early records of Little Penguins suggested burrow totals of some hundreds (Gillham 1961), but later observations considered that up to 4000 were present (Thoday 1991). Similarly, the number of Short-tailed Shearwater and their extent have also increased, from the '(m) any thousands' in 1959 (Gillham 1961) to an es-

timated total of around 131 000 in 1978 (Harris and Norman 1981) and 210 000 in 1991 (Thoday 1991), a total subsequently reduced (to 100 000 in 1995 (Thoday 1995c). Shearwaters' burrows had advanced considerably into the previously eroded areas now mainly stabilised by *Poa poiformis*. Further, the Cape Barren Goose, which was not seen on the island before 1978 when breeding was first recorded, now breeds in substantial numbers, and its increase is likely to have resulted from reduced persecution elsewhere around Wilsons Promontory, and perhaps improved forage on the island itself (following rabbit removal).

In contrast to many control operations conducted elsewhere (see Reddix *et al.* 2006), the removal of rabbits from Rabbit Island has been followed for many years. In the study period from 1965 (if not 1959) to 2002, eroded areas have disappeared and have been covered by local vegetation, cover by shrub species has increased (and used by a nesting passerine, the Forest Raven), population growth of shearwaters and penguins has occurred, Cape Barren Geese have established numerous breeding pairs, and a range of passerine species has been recorded in the enhanced flora, whose unburnt development has been more than 'anecdotal' (Reddix and Forsyth 2006). Nevertheless, the bird species recorded on the island may be transients rather than residents, perhaps reflecting the relatively 'simple' vegetation communities present. The increase in biodiversity of plants and birds and the apparent increase in abundance of burrowing seabirds on Rabbit Island following the removal of rabbits, strongly supports their removal from other Bass Strait islands, such as Lady Julia Percy (Dann *et al.* 2004).

Acknowledgements

It is a pleasure to acknowledge the bird (and vegetation) observations provided by members of the Penguin Study Group. While RT and SU have previously summarised some results, it should be realised that many Group members (see references cited) took part in the numerous visits to Rabbit Island. We are also grateful to Parks Victoria and the Department of Sustainability and Environment for permission to visit the island, to those involved in transporting the various observers, and to Parks Victoria, particularly Don Saunders, who managed to eradicate rabbits from the island very efficiently and who facilitated access over the years, the editor and two anonymous referees for their helpful comments. We are grateful to Nicole Schumann from Deakin University for

the photograph. Finally FIN would like to note that ME Gillham was responsible for his initial interest in matters relating to Bass Strait, where she had established an ecological background that was a pleasure to revisit and elaborate on.

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Annual mowing of a grassland had minimal effect on botanic composition during a period of changed climate (or prolonged drought)

Bill Semple¹, Terry Koen^{2,3} and Madeleine Rankin²

¹ 37 Popes Rd, Junortoun, Victoria 3551

² NSW Department of Environment, Climate Change and Water, PO Box 445, Cowra NSW 2794

³ Corresponding author. Email: Terry.Koen@environment.nsw.gov.au

Abstract

Prolonged drought, as has been experienced over much of the wheat-sheep (or grassy woodland) zone of southern New South Wales during approximately the last 15 years, is equivalent to a change in climatic zone from subhumid to semi-arid. One of the symptoms of this is less reliable rainfall, particularly during the normally dependable autumn–winter period. As demonstrated by the results of a 7-year experiment in a grassland near Molong in Central Western NSW, this change, if permanent rather than temporary, has implications for ecological experiments that aim to change botanic composition using various manipulatory techniques. At Molong, significant differences in botanic composition were evident over time but not between treatments. It is suggested that this result can be explained by the prevailing rainfall regime during the period of observation and that different results may have been obtained if rainfall had been more closely aligned to the long-term average. (*The Victorian Naturalist* 127 (5), 2010, 168–173).

Keywords: cool-season rainfall, derived grassland, gap-creation, mowing

Introduction

On the inland slopes and plains from central New South Wales (NSW) to Victoria, cool-season (autumn and winter) rainfall is a major driver of landscape processes. These include the refilling of wetlands, the flush of growth of cool-season plant species, and the replenishment of subsoil moisture for growth of warm-season species over summer when rainfall is less effective. A key feature of cool-season rainfall in this area has been its reliability — a feature that also has permitted successful farming in the ‘wheat-sheep’ belt, the subhumid climatic zone (usage according to Read 1994) formerly occupied by grassy woodlands; however, in recent years, cool-season rainfall has been far from reliable. An analysis (Semple *et al.* in press) of cool-season (March–August) rainfall from 1885–2008 at Cowra NSW indicated that, in terms of rainfall received and the frequency of below-average* seasons, the 15-year period 1994–2008 was drier than any other equivalent period since records commenced. Whether this can be considered another prolonged drought like those that occurred at the turn of the 19th century and in the mid-20th century, or a result

of a permanent change in climate, is still being debated. However, as noted by Read (1994), prolonged drought results in at least a temporary change in climate; and, in the wheat-sheep belt, this has resulted in a change from a predominantly subhumid climate to a semi-arid climate.

A characteristic of many semi-arid and arid lands is high variability in annual rainfall that results in varying levels of abundance of plant species in the groundstorey with time. In their summing-up of vegetation ecology and management in Australia’s rangelands, Harrington *et al.* (1984: 60) emphasised the differences between reliable and unreliable climates as follows:

‘In a reliable climate ... it is possible to plan a grazing and/or fire management regime which is responsive to the rainfall regime and takes into account the life-histories of the key plant species, and thereby obtain a measure of control over the composition of the plant community. In unreliable climates the acquisition of such knowledge is much more difficult because any particular run of rainfall events is infrequently repeated and may give an effectively unique vegetation response.’

*Throughout this report, ‘average’ is equivalent to mean.

The effects of drought on components of the flora include failure to germinate, germination followed by early death, reduced seed production, and death of perennial species. When aggravated by chronic overgrazing, a permanent change in groundstorey composition may occur, as has been reported in the semi-arid rangelands (e.g. Noble 1997). Rains do occur during prolonged drought but in lower amounts during the season when they are expected (at least in most years), and heavy rainfalls may occur at unexpected times (e.g. see warm-season rainfall for 2005/06 in Fig. 1). In the latter case, some species may be advantaged by low groundcover and/or the absence of species that normally would be present.

This raises the question of whether the results and conclusions of 'paddock-scale' experiments (i.e. those involving assemblages of organisms) carried out in more benign times, when cool-season rainfall was adequate and reasonably reliable, are applicable during a prolonged period of unreliable rainfall. Conversely, will the results of field experiments carried out in the last 10 or 15 years be applicable when or if rainfall returns to a level that is more closely aligned with the long-term average?

Among the paddock-scale experiments that could be affected by a change in climate (temporary or permanent) are those relatively long-term studies that attempt to manipulate groundstorey composition by one-off or sequential biomass-removing disturbances such as crash grazing, burning and mowing. Such disturbances create canopy gaps that, depending on the time of year they are created and on the type of groundstorey, may be beneficial (e.g. Morgan 1998) or deleterious (e.g. Lunt 1990) for biodiversity conservation. Gap-creation exercises are likely to be ineffective in environments that are limited by low rainfall (e.g. semi-arid rangelands) and/or low fertility, as gaps are usually already present (Lunt 2007).

One site selected for such an experiment was in derived grassland in an unused part of the cemetery at Garra, 10 km west-south-west of Molong, on the Central Western Slopes of NSW. The site was fertile, dominated by exotics (a probable consequence of grazing many years previously) and Speargrasses (*Austrostipa* spp.). It was hypothesised that, depending on the time that gaps were created by mowing,

different species would be favoured whereas others would be discouraged if they were seeding at the time mowing occurred. All slash was removed, as this was considered to discourage exotics (e.g. see Verrier and Kirkpatrick 2005) and could be compared to crash grazing where selective grazing is negated.

An implicit assumption at the time the experiment commenced in 1999 was that rainfall would be 'average', i.e. approximately 350 mm in the cool-season with a similar, though less effective amount, in the warm-season. As can be seen from Fig. 1, this did not occur. Severe deficiencies occurred in 2002 and 2006, and cool-season rainfall was below average every year after 2001.

Methods

The experimental area was divided into 18 contiguous 6 m x 5 m plots: three rows (blocks) of six treatments. The five mowing treatments, annual mowing in either mid-summer, mid-autumn, mid-winter, mid spring, or mid-autumn + mid-spring, and unmown were randomly allocated to plots in each block. At each mowing, herbage was cut to a height of approximately 4 cm and clippings removed by hand raking. Treatments were applied in the relevant season(s) from summer 1999/2000 to spring 2007. Abundance of species in each plot was assessed in December 2000, October 2001, November 2003 and October 2005 using Outhred's frequency-scores as described by Morrison *et al.* (1995) [obtained by laying out seven rectangular quadrats that increased geometrically in size from the inner to outer-most quadrat, and recording presence/absence of rooted plants of each species in each quadrat]. Individual species in each plot were also assessed semi-quantitatively using a modified Braun-Blanquet 0-7 cover-abundance scale in October 2007.

After eliminating 11 species recorded in only one plot and on only one occasion, the remaining species were examined in two ways:

The data matrix of the 71 species was converted to a similarity matrix using Bray Curtis similarity coefficients contained within the PRIMER (Version 5) statistical package (Clarke and Gorley 2001) and analysed using non-metric Multi-Dimensional Scaling (MDS). The degree of association of individual plant species with the treatments and times and their interactions was measured by Indicator Species Analysis us-

* Botanical nomenclature follows that of Harden (1990-93).

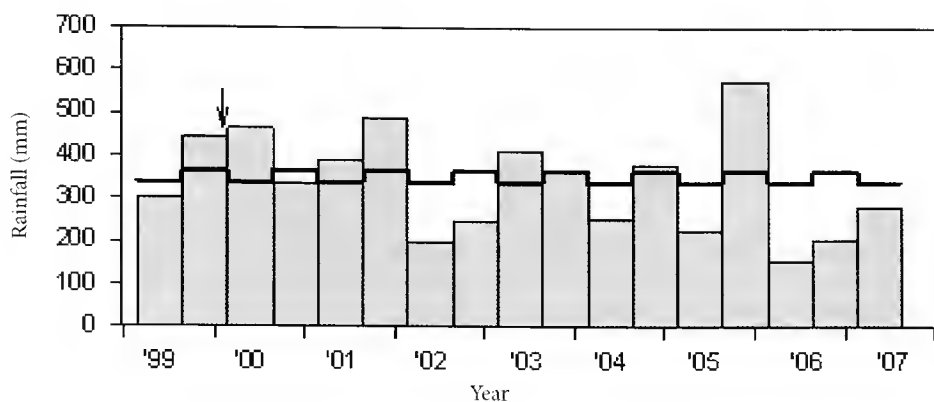


Fig. 1. Cool (March–August) and warm (September–February) season rainfall at Molong (Bureau of Meteorology Station 065023) prior to and during the mowing experiment at Garra. Thickened line indicates long term (1884–2007) seasonal means. Arrow indicates the initiation of mowing.

ing PC-ORD (McCune and Mefford 1999). The indicator value is maximal ($IV=100$) when all individuals of a given species are restricted to a particular treatment or time, and all samples from the particular treatment or time contain an occurrence of that species.

Univariate analysis of variance was performed on mean frequency-scores and mean numbers of species within species groups, viz. native perennials (33 species across all plots and times), native annuals/biennials (6 species), exotic perennials (6 species) and exotic annuals/biennials (26 species).

Results

Differences in species composition between treatments were undetectable until 2005 when a marginal difference ($P = 0.06$) between the unmown control and the treatment with the highest level of disturbance, viz. spring+autumn mowing, was evident.

However, the occurrence and abundance of many species was very time-dependent. The Indicator Species Analysis showed that the abundances of approximately half the species were significantly higher ($P \leq 0.05$) in a particular year: for eight species in 2000, another six in 2001, three in 2003 and 15 in 2005.

Univariate analyses also indicated significant differences ($P \leq 0.001$) in the mean frequency-scores within all species groups over time (e.g. Fig. 2) and in the mean numbers of species within the groups, except for exotic perennials. Differences between treatments ($P \leq 0.05$)

were not detected except for the small group of native annuals/biennials. Visual inspection of the graph of the latter (Fig. 2a) suggested that differences were highest in late 2005 when mean frequency-scores in the spring and autumn+spring mowing were elevated relative to the control — a trend that also was evident in the cover-abundance data for late 2007.

A distinctive feature of the results was the number of species that were recorded in only one or two seasons. Of the 82 species/species groups that were observed in the four quantitative observations, together with another two that were observed only in the last (semi-quantitative) observation in 2007, 25 were infrequently-recorded: 13 in only one season and 12 in only two seasons. At the last observation in 2007, 29 species (of which 17 were in the infrequently-recorded group) were absent and 12 of these were also absent at the previous observation in 2005. Amongst the last-mentioned were the once relatively common weeds, Viper's Bugloss *Echium vulgare*, Salsify *Tragopogon porrifolius* and Twiggy Mullein *Verbascum virgatum*.

Discussion and conclusions

The results suggest that the effects of annual mowing in different seasons had minimal effect on species composition over a 7-year period. Some minor differences between treatments were evident in 2005, but whether they were a result of cumulative mowing effects (as was expected) or seasonal effects (2005 was an un-

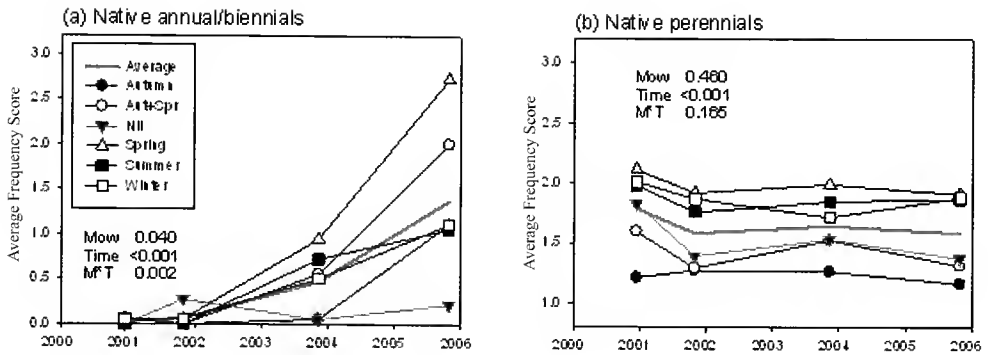


Fig. 2. Mean ($n = 3$) frequency-scores for (a) native annuals/biennials and (b) native perennials in all treatments at Garra from mid December 2000 to late October 2005. F probabilities from ANOVA for mowing treatment effect, time effect and their interaction are shown within each graph.

sual year with well above-average spring rainfall) is uncertain.

There are a number of possible explanations for the lack of treatment effects. Firstly, it could be argued that the monitoring technique was insufficiently sensitive to detect changes in species composition. The methodology put the observer in close proximity with the plants present in each plot and it is believed that all species present were detected. However, the process was somewhat destructive, particularly during dry times, and was the main reason why the technique was discontinued after 2005. Furthermore, the technique did not distinguish between healthy plants and those that were drought-affected.

Secondly, the annual (and in one treatment, biannual) mowings may have been too benign to have had any measurable effect. This was unlikely, as the aim of the mowing was to create gaps in the vegetation and to remove seedheads at particular times of the year, however, as discussed below, seedhead production was seasonally variable and gaps were not always fully exploited. In any case, even biennial mowing has been reported to affect grassland structure and species (albeit cryptogam) composition (O'Bryan *et al.* 2009).

Thirdly, it could be argued that the type of groundstorey, e.g. with a preponderance of naturalised species, was inherently stable and unlikely to change. Yet this was not the case as groundstorey composition changed significantly from year to year regardless of treatment,

a result that would be expected in a more semi-arid region subject to variable rainfall.

The most likely explanation for the lack of expected differences between treatments was the variable and often below-average rainfall that prevailed for most of the time the experiment was carried out. This is not a novel explanation. Following pasture manipulation, including slashing, experiments at four sites during 1993–96, Garden *et al.* (2000) reported minimal difference between treatments and attributed the result to prevailing drought. With respect to two sites, they noted that changes in pasture composition occurred only 'when rainfall returned to average or above average after at least 12 months of drought' (Garden *et al.* 2000: 243). Perhaps the marginal differences between treatments that we observed in 2005 were akin to this.

Without sufficient rainfall at appropriate times, it is unlikely that gaps will be fully colonised and it was noted at Garra that as dry conditions intensified after 2001 there was always some bare ground (gaps) in the treatment plots; so in this respect, any one treatment was much the same as another. Furthermore, the production of seedheads was variable over time, particularly in the case of Speargrasses where seed crops were minimal in some years. Removing seedheads by mowing and raking at the time they were normally produced would have had little differential effect if few seedheads were present anyway. Furthermore, Speargrasses can reappear after suitable rainfall despite being ab-

sent for many years, suggesting that they have persistent seedbanks (Grice and Barchia 1992). Hence, raking may not have had a dramatic effect on subsequent germination.

More importantly, however, was that the abundance of many species was significantly aligned with a particular season; i.e. the composition of the groundstorey in all treatments, including the control, was changing throughout the period of observation. This was more consistent with observations in semi-arid and arid areas where groundstorey composition can vary markedly from year to year. Different plant functional groups use water at different times, and vary in the efficiency with which they use rainfall of differing duration, intensity and amount (Westoby 1979/80). This creates opportunities for different communities to develop in response to differing modes and types of rainfall, favouring different suites of species depending on the rainfall. Increasing rainfall variability increases the dominance by annuals, and studies of annuals in more arid areas (e.g. Tobe *et al.* 2005), indicate that rainfall regime is the most critical factor affecting variable establishment successes of different annual species.

We do not know to what extent results of this experiment would have been different in 'normal' or even high rainfall years and we are most reluctant to generalise our findings to those conditions. We suspect, however, that much of what we observed at Garra was a consequence of variable and often insufficient rainfall as well as a progressive drying of the site.

Our results are probably more consistent with expectations from the semi-arid zone (Mott 1972) than from the subhumid to humid zones. In the former, changes in a chronic management regime may take a longer period to become evident — or, as noted by Westoby *et al.* (1989), be particularly dependent on an infrequent environmental event.

Regardless of whether or not readers accept our suggestion, viz. that the results may be applicable to another (less favourable) rainfall zone than the one in which the site was nominally located, a question remains: are the results of experiments carried out during drought relevant to ecology? In the case of an 'ordinary drought' or an extended dry period extending across one or two years, our knowledge is perhaps sufficient to predict the consequences on assemblages of plant populations. But in the

case of exceptionally prolonged drought that occurs once in a century, we clearly do not have sufficient information — unless we are prepared to extrapolate findings from adjacent drier climatic zones.

For years, farmers and graziers have been advised (e.g. Heathcote 1969) that droughts are normal events for which they should be prepared. Following each of the droughts of recent years, information, predominantly anecdotal, has been compiled into 'effects and lessons from the drought' publications (e.g. Malikides *et al.* 1969; Austin *et al.* 1995). As a result of predictions of more frequent and severe droughts due to 'climate change' (e.g. Stokes *et al.* 2008), advice on drought effects has become more urgent. Yet what do experimental field ecologists do when the expected rains do not occur during their usual 3-year time-frame? Some are advised by their supervisors to irrigate their plots 'up to average rainfall' or carry out concurrent glasshouse pot trials. Altering experiments in such a way may mean that we lose the opportunity to learn more about the consequences of a more variable and sub-average rainfall regime on more mesic ecosystems. Nevertheless we acknowledge that some specifically drought-oriented ecological reports have been published recently (e.g. Croft *et al.* 2007; McKeon *et al.* 2009) and hopefully more will follow.

Much can be learned about the response of more mesic vegetation communities to reduced and more variable rainfall by observing how semi-arid plant communities respond to rainfall variability. In the case of our study at Garra, the plant community exhibited a response to rainfall that was typical of a semi-arid community. Results of studies such as ours — even if 'negative' — may provide valuable guidance if the change in climate from subhumid to semi-arid becomes permanent rather than temporary.

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One hundred years ago

EXCURSION TO WEST WARBURTON

A.D. Hardy

From "The Rock," in suitable weather, a magnificent view can be obtained, and for this alone the climb is justified. The day was too hazy to make out through our field-glasses any of the prominent, land-marks of Melbourne, forty miles away, but the pine trees on the hill at Ringwood were distinctly visible, while Mounts Macedon and Baw Baw, about a hundred miles apart, bounded our view to the west and east. To the north the sharp cone of Mt. St. Leonard was just visible through the trees. We looked over "Nyora," and Malleson's Look-out to Healesville, but the most delightful view was down into the Yarra valley, nearly three thousand feet below us, where the three townships of West Warburton, Millgrove, and Warburton were prominent features. An apparently level ridge led round eastwards to Donna-Buang, while southwards range and valley succeeded one another as far as the eye could reach. The position of Gilderoy, where we had intended to explore, could just be made out among the ranges about ten miles to the south-east. We returned by a more direct route, and from the Dee valley brought away several species of ferns and seedling plants, including an *Eriostemon*, probably *E. squamens*, some of which are destined to find their way into public gardens after a period of pot-life.

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A preliminary assessment of the potential of shelterbelts to maintain spider diversity within agricultural landscapes

Kylie B Malic

Biosciences Research Division, Department of Primary Industries, PO Box 48, Ballarto Road, Frankston, Victoria 3199

Abstract

A once-off pilot study was conducted in north-eastern Victoria to assess the spiders associated with two agricultural landscapes (a vineyard and a grazing property). The study found a total of 225 individual spiders from 19 families. No significant differences were found in the number of families of spiders or total spider abundance between the paddocks and adjacent shelterbelts. However, it is suggested that more sampling on several seasonal occasions may reveal differences because preliminary results indicate that certain spider families have preferences for particular habitat factors (such as the availability of vegetation on which to build webs, or the openness of the ground layer). (*The Victorian Naturalist* 127 (5) 2010, 174-177).

Keywords: shelterbelts, spider diversity, natural enemies, habitat preferences

Introduction

Agricultural practices since European settlement have altered the Australian landscape considerably, and subsequently led to a simplification of vegetational environments. The uniform nature of such landscapes has generally resulted in a loss of biodiversity, including spiders. Non-crop habitats, such as shelterbelts, are now being widely used in Australia to combat land degradation, as well as potentially helping to reduce biodiversity loss by increasing the diversity of vegetation within the agricultural landscapes (Tsitsilas *et al.* 2006).

Spiders are an important component of the food chain in that all species are predatory, and this short study was conducted to assess spiders associated with agricultural landscapes. Spider taxonomy is based primarily on mature males, and identification of females and immature spiders to species is often difficult; however, identification to the family level is easier, and each family can be assigned to a particular hunting strategy (Churchill 1998), and the composition of the spider assemblage can be considered on the basis of family composition. Since heavily modified agricultural land may result in the loss of suitable foraging surfaces for hunting spiders or scaffolding for web-builders (Churchill and Ludwig 2004), the structure of the surrounding environment

becomes very important for promoting spiders as predators within an agricultural landscape. Studies from New Zealand and Germany have found that heterogeneous environments can support more invertebrates and more spider species than adjacent pastures (Clough *et al.* 2005; McLachlan and Wratten 2003), although the response of each spider will depend upon its size, mobility, behavioural characteristics and life history (Soulé and Gilpin 1991; Martin and Major 2001). A pilot study, conducted over a short time frame, was undertaken to assess whether shelterbelts in Victoria have a higher richness and abundance of spiders than adjacent paddocks, and if spider family assemblages display preferences for particular microhabitats across these boundaries.

Methods

Study sites were selected from two Victorian farming properties — a vineyard in Rutherglen (36° 1' 43.23" S 146° 36' 27.49" E), and a lucerne property in Picola (35° 59' 6.81" S 145° 8' 43.08" E). The sites were selected to allow comparisons of invertebrate fauna in the shelterbelt and the adjoining agricultural landscape. The shelterbelt at Rutherglen is bordered by vines on both the southern and northern side, creating three sub-sites. Picola consisted of two sub-sites, with a lucerne paddock being located on the southern side of the shelterbelt. Replicate sampling

units consisted of three transects set up perpendicular to the shelterbelt-paddock border.

Ground-active invertebrates were sampled using pitfall traps, and above ground taxa were collected using water traps. The pitfall traps were 70 mm in diameter and partially filled with ethylene glycol. Yellow water traps measuring 180 x 120 x 65 mm were filled with water and a drop of detergent. There were 13 sampling points per transect at Rutherglen (five in both paddock sub-sites at distances 10, 20, 30, 40 and 50 m from the shelterbelt, and three within the shelterbelt at 10 m spacings). There were six sampling points per transect at Picola (five in the paddock at distances 10, 20, 30, 40 and 50 m from the shelterbelt, and one 5 m into the shelterbelt). In the paddock sub-sites, pitfall traps were placed at the 10, 30, and 50 m sampling points and water traps at 20 and 40 m. In the shelterbelt sub-sites, pitfall traps and water traps were used at each sampling point.

At each location the traps were all primed on the same day and opened for one week. The traps at Rutherglen were run from 8-15 November 2004, and those at Picola from 9-16 November 2004. When collected, the water traps were passed through a 1 mm sieve to drain the trapping fluid, and then placed into a specimen jar containing 70% ethanol. Mature and immature spiders were sorted to family level (Raven *et al.* 2002).

Summary statistics of spider family richness and total spider abundance were recorded for each site, as well as observations on habitat preferences for some of the dominant spider families. Analysis of variance (ANOVA) was used to test for differences in spider abundance and spider family richness between shelterbelts and adjacent agricultural paddocks. Spider abundance data were averaged per trap and log+1 transformed for normality.

Results

A total of 225 spider individuals from 19 families was collected and identified. A further six individuals could not be identified with any confidence and had to be discarded from the analysis. Spider assemblages show some trend with respect to shelterbelt or paddock location, with mean spider abundance and family richness slightly higher within the shelterbelts (Table 1); however, the results were not significantly different (abundance: $F_{(1,13)} = 0.03$, $P = 0.871$; family richness: $F_{(1,20)} = 2.62$,

$P = 0.121$) possibly due to the low sampling effort. The only exception to this trend was found within the water traps at Picola for spider family richness.

Habitat location preferences were observed for a selected group of spider families sampled (Table 2). These observations were limited to the dominant families where predominantly mature spiders were collected. Linyphiidae and Dictynidae show a pattern of preference for paddock environments over shelterbelts, while Salticidae were trapped only within the shelterbelt. Lycosidae appear to have a wide habitat range, being consistently collected both within the shelterbelt and in all pitfall traps up to 50 m into the paddocks.

Discussion

This study has shown that, although there are differences in spider family diversity and abundance of spiders between shelterbelts and adjacent paddocks from two farming systems in north-eastern Victoria, the differences are minor. The low sampling effort meant that it was difficult to analyse the data statistically, and it is probable that with an increased sampling effort these differences would become statistically significant. The only exception to this trend was with the water traps from Picola, where more families were collected from the adjacent paddocks than the shelterbelts. This irregularity may be related to the trapping technique since water traps target flying insects and are, therefore, not an ideal technique for trapping spiders. However, the shelterbelts studied were more vegetationally diverse than the adjacent crops and, since habitat heterogeneity increases the availability of habitats for spiders (Churchill and Ludwig 2004), shelterbelts can potentially increase the number of natural enemies to crop pests within a system. Therefore, incorporating shelterbelts into agricultural landscapes may have a positive effect on crop management in terms of increasing potential natural enemies.

This study indicated that certain spider families show preferences for particular habitats. Although spiders are often classified as generalist predators, they do include specialist predators, so the variance in location may depend on the family's primary foraging mode.

The preference for paddocks shown by Linyphiidae is supported by a number of studies (Sunderland and Samu 2000; McLachlan and

Table 1. Mean abundance of spiders and family richness for shelterbelt and paddock sub-sites at Picola and Rutherglen.

		Mean abundance		Family richness	
		Shelterbelt	Paddock	Shelterbelt	Paddock
Picola	Pitfall traps	1.83	1.75	6.33	4.33
	Water traps	1.10	1.06	3.0	6.0
Rutherglen	Pitfall traps	1.63	1.28	5.0	4.67
	Water traps	1.09	0.92	3.33	3.17

Table 2. Dominant spider family abundances with distance from shelterbelt at Picola and Rutherglen.

		Distance from shelterbelt					
		Shelterbelt	10 m (pitfall)	20 m (water)	30 m (pitfall)	40 m (water)	50 m (pitfall)
Picola	Linyphiidae	2	7	1	12	2	1
	Dictynidae	0	1	0	2	1	0
	Salticidae	2	0	0	0	0	0
	Lycosidae	7	4	0	5	1	7
Rutherglen	Linyphiidae	1	0	1	0	3	0
	Dictynidae	1	7	0	0	0	1
	Salticidae	6	0	0	0	0	0
	Lycosidae	11	7	0	3	0	1

Wratten 2003; Clough *et al.* 2005). This may be related to the potential for dispersal offered by ballooning, but linyphiid spiders are sheet web spiders often found between low leaves, so the vines and lucerne may have provided a suitable environment of low leaves to which these spiders could disperse and subsequently build webs necessary for capturing prey. Again, the preference for the paddock environment shown by Dictynidae may be associated with this family's capability of establishing in these types of agricultural systems, because the vegetational structure of the vines and lucerne allows the spiders to colonise the extremities of small branches to form their irregular three-dimensional webs.

Salticidae are diurnal hunters that use their highly developed visual system to stalk prey actively across complex vegetation surfaces. Churchill and Ludwig (2004) found that declines in salticid abundance were significantly related to the reduction in cover of perennial grass patches and tree canopies. Therefore, changes in grass and tree canopy cover across

the shelterbelt-paddock boundary may explain why these spiders were collected only from the shelterbelts in this study.

The wide range of Lycosidae is supported by a number of Australian studies (Bishop 1981; Major *et al.* 2006). Lycosids are habitat generalists and strong running hunters, so are unlikely to be affected by shelterbelt-paddock boundaries. Furthermore, these spiders may be dispersing from the complex shelterbelts into the relatively bare ground cover of the adjacent paddocks to find suitable habitat in which to search for prey, as studies have shown that lycosids prefer a low cover of grasses or less complex ground covers for foraging (Churchill 1998; Martin and Major 2001; Churchill and Ludwig 2004).

Since mobility, behaviour and hunting strategies have a clear effect on spider distribution within an environment, the structure of the environment becomes very important when choosing to promote certain spiders as predators. Vegetation that promotes web-building would be preferential for

controlling flying pests because these pests are generally captured by orb-web spiders. Yet, complex vegetation surfaces that allow wandering spiders, such as the salticids, to stalk non-flying pests would help increase preying efficiency of these spiders. So, while these characteristics must be taken into account in order to maximise the efficiency of using particular spiders as natural enemies, by maintaining habitat heterogeneity within an agricultural landscape we help to preserve the diversity of spiders, which intrinsically increases general preying efficiency.

This study demonstrated some initial findings that indicate advantages to maintaining shelterbelts within Victorian agricultural systems, but this was a preliminary study and therefore has certain limitations. First, the fauna was sampled only once and, since seasonality has a major influence on invertebrates, it is likely that only a snap-shot of what is happening was revealed. Second, only two collection techniques were used. While pitfall traps may have adequately targeted ground-dwelling spiders, canopy-dwelling spiders were likely to be under represented and may have been better targeted with collection techniques such as beating or sweeping (Neville and Yen 2007). The next step in examining the potential of maintaining spiders within Victorian agricultural systems would be to increase the sampling effort by including more sites, more replications, and taking into account seasonal collections. Furthermore, a more intensive survey that concentrates on the movement of spiders between the shelterbelt and agricultural system could help to indicate whether shelterbelts adjacent to seasonal cropping systems provide a good refuge for spiders in the off season when paddocks are bare.

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Factors contributing to Platypus mortality in Victoria

Melody Serena and Geoff Williams

Australian Platypus Conservancy, P.O. Box 22, Wiseleigh, Victoria 3885

Abstract

Of 124 Platypus mortality records from the 1980s to 2009 where the cause of death could be reliably assigned, 41% were deemed to be due to animals drowning in nets or traps set to capture fish or freshwater crustaceans, with fyke nets and opera house traps mainly responsible for Platypus deaths since 2000. By comparison, 26% of mortality records were ascribed to natural causes (predation by raptors and canids, flooding and drought), though natural causes were almost certainly under-reported. Other important factors contributing to mortality included litter and fishing hooks (14% of mortality records), man-made structures such as irrigation gates and pumps (10%) and motor vehicles (4%). (*The Victorian Naturalist* 127 (5) 2010, 178-183).

Keywords: Platypus, mortality factors, illegal netting, litter entanglement, effect of floods

Introduction

Platypus *Ornithorhynchus anatinus* have been documented to be preyed upon by a variety of species, including wild Dog *Canis familiaris* and Fox *Vulpes vulpes* (Brown and Triggs 1990), Spot-tailed Quoll *Dasyurus maculatus* (Dawson *et al.* 2007), Tasmanian Devil *Sarcophilus harrisii* (Munday *et al.* 1998), White-bellied Sea-Eagle *Haliaeetus leucogaster* (Munday *et al.* 1998; Seale 2008), Wedge-tailed Eagle *Aquila audax* (Rakick *et al.* 2001), Grey Goshawk *Accipiter novaeollandiae* (Richards 1986) and Carpet Python *Morelia spilota* (Burrell 1927). The earliest evidence that Platypus were hunted for food by Aborigines consists of bones found in Tasmanian caves occupied between 13 000 and 30 000 years ago (Marshall 1992).

Following European settlement, many Platypus were killed for sport or as a source of fur. For example, a self-styled 'naturalist' named Bob Stuart reportedly made a fairly good living in the 1870s by selling the skins of Platypus trapped or shot along Darebin and Merri Creeks and nearby parts of the Yarra River, in what are now Melbourne's inner suburbs (Ward 1966). More recently, factors contributing to Platypus mortality include floods (Grant 2007), litter entanglement (Serena and Williams 1998), being shot (Munday *et al.* 1998), run over by motor vehicles (Tyson 1980; Taylor *et al.* 1991; Otley and le Mar 1998) or injured after entering power plant intakes (Munday *et al.* 1998), becoming wedged in narrow pipes (Taylor *et al.* 1991), drowning in fish nets and yabby traps (Munday *et al.* 1998) or after becoming snagged on fish

hooks (Grant 2007) and dying in rabbit traps (Burrell 1927). However, to date, only one study has assessed the relative importance of different mortality factors. Based on necropsies of 25 carcasses carried out in Tasmania in the mid-1990s, Connolly *et al.* (1997) concluded that 40% of Platypus deaths were due to attack by dogs, 28% were caused by motor vehicles, 16% were attributable to starvation and/or exposure (including one animal that had been washed downstream by flooding) and 8% were due to infection by *Mucor amphibiorum*, a fungus linked to disease in Tasmanian Platypus but not animals living on the Australian mainland. The cause of death could not be reliably assigned in the remaining 8% of cases.

Factors implicated in contributing to Platypus mortalities in recent decades in Victoria are reported here, based mainly on carcasses discovered fortuitously by a wide range of informants. In addition, data relating to the effect of flooding on Platypus was obtained as a by-product of live-trapping surveys carried out by the authors in and around Melbourne from 2001 to 2006.

Methods

From 1989 to 2009, the authors recorded details of 174 first-hand verbal reports of Platypus mortalities, including 23 cases in the 1980s, 60 in the 1990s, and 91 in the 2000s. The reports were provided on an ad hoc basis by veterinarians, biologists, natural resource managers and members of the public. Most reports (71%) were provided within 4 weeks or less of a carcass being found or death(s) otherwise being

documented. Whenever possible, informants supplied photographic documentation of the remains ($n = 39$) or held them until the remains and the place where they were found could be examined by Australia Platypus Conservancy staff ($n = 41$).

Platypus live-trapping methods used to provide information relating to the effects of flooding on Platypus survival have previously been described in Serena (1994) and Easton *et al.* (2008).

Results

Factors contributing to death were not assigned in 50 cases due to inadequate evidence, i.e. Platypus remains were found without any compelling indication as to how the animal(s) died. The remaining 124 cases were attributed to a diverse range of agents and events, broadly grouped into 10 categories (Table 1).

Illegal nets and traps

In 41% of the cases where cause of death could be reliably identified, animals drowned in nets or traps set to capture either fish or edible crustaceans such as Yabbies (*Cherax* spp.) or Spiny Crayfish (*Euastacus* spp.). Many of these incidents involved multiple Platypus mortalities. For example, in the mid-1990s reservoir management staff found at least eight carcasses tangled in a pair of rectangular mesh gill nets (each c. 10 m long) lying next to Cairn Curran Reservoir near Welshmans Reef Caravan Park (confirmed by photographic evidence). The nets presumably had been attached to nearby dead trees standing in the water and were abandoned after they had been discovered to have killed protected wildlife as well as fish. Among reports received since 2000, the authors confirmed that 17 Platypus skulls were contained in a single unlicensed fyke (or eel) net set and then abandoned along a small stream in the Gellibrand River catchment, and five carcasses were discovered by a state wildlife officer in a pair of licensed fyke nets set about one km upstream of the area legally allocated to commercial eel fishing along the Tarra River. Up to three animals at a time have reportedly died in a single enclosed yabby or cray trap when a landowner reported finding 'one very large and two smaller' individuals drowned in an opera house net set in the Tarago River in 2006.

Drum nets and enclosed yabby/cray traps each were involved in one-third of incidents

where the type of net or trap was unambiguously identified, followed by fyke nets (24%) and gill nets (9%). Although admittedly based on small samples, mortalities related to use of drum nets seem to have dropped since 2000, whereas those related to use of yabby/cray traps appear to have increased (Table 2).

Predation

Nearly one-fifth of Platypus mortality reports were related to predation. Carcasses were found 8 to 100 m from the nearest water body (55 ± 24 m, mean \pm S.D., $n = 15$), presumably having been carried from the water's edge after being killed. Three carcasses had wounds that appeared to be caused by a raptor's talons and/or bill. The remaining 21 deaths were attributed to canids (dogs or foxes). Most commonly, this was based on severe thoracic bruising and broken ribs being recorded along with puncture marks corresponding to a canid's canine teeth ($n = 4$), or a crushed skull and/or broken neck occurring in conjunction with tooth puncture marks ($n = 12$). In addition, one partially eaten carcass was found buried in a pile of sand (with fox tracks and evidence of digging activity observed at the site the morning after the carcass was removed), one partially eaten carcass was found close to a Fox den, and three partially eaten carcasses were recovered in association with fresh canid scats and/or tracks.

Juveniles (< one year old) appear to be more vulnerable to predation than older animals. Of 16 carcasses that could be assigned to an age class based on the size and appearance of spurs located on a platypus's hind legs (Temple-Smith 1973), six individuals were classified as adults or subadults (3 males, 3 females) and 10 as juveniles (4 males, 6 females). Interestingly, mortalities due to predation were recorded in every month from November through June but not July, August, September or October. This presumably reflects the fact that unregulated Victorian streams and rivers typically flow most strongly in winter and spring, helping to protect Platypus from land-based predators.

Man-made structures in channel

Thirteen mortality reports (10% of the total) were related to animals drowning after encountering man-made structures. A large proportion of these reports ($n = 8$) involved a Platypus entering an irrigation pump, with cases recorded along the Thomson and Murray Rivers

Table 1. Factors deemed to be responsible for Platypus mortalities in Victoria from the 1980s to 2009.

Mortality factor	No. of incidents (%)	No. of animals (%)
Illegal nets	51 (41%)	103 (56%)
Predation	24 (19%)	24 (13%)
Structures in channel	13 (10%)	19 (10%)
Angling	10 (8%)	10 (5%)
Litter	7 (6%)	7 (4%)
Flooding	5 (4%)	5 (3%)
Motor vehicles	5 (4%)	5 (3%)
Shot or bludgeoned	4 (3%)	4 (2%)
Drought	3 (2%)	3 (2%)
Miscellaneous	2 (2%)	3 (2%)
Total	124	183

Table 2. Temporal variation in the use of four types of nets or traps contributing to Platypus mortality in Victoria.

Net type	No. of mortality reports		
	1980-1989	1990-1999	2000-2009
Enclosed yabby/cray trap	2	2	7
Drum net	4	6	1
Fyke net	2	2	4
Gill net	1	1	1

in the 1980s and 1990s, and the Loddon, Yarra and King River catchments and lagoons associated with Gunbower Creek after 2000. Most landowners responded by fitting grates or the equivalent around the pump structure, but two or more animals died sequentially over time in the case of three pumps. In addition, one Platypus died after entering a small, privately owned hydroelectric turbine via an unguarded inlet, one died while attempting to negotiate a Dethridge wheel (used to monitor the delivery of irrigation water), one drowned after becoming lodged in a small pipe associated with a town water supply system, one drowned while attempting to squeeze through a narrow (c. 5 cm) gap between gates used to regulate flow between irrigation channels, and one drowned while attempting to negotiate two overlapping wire mesh panels used to trap incoming leaves at the upstream end of a small on-stream dam.

Angling

Ten reports (8% of the total) described animals dying as a direct or indirect by-product of angling. Three cases involved animals found dead at the water's edge with one or more loops of nylon fishing line wrapped tightly around the neck or torso. In each case, the line had cut

deeply into underlying muscle and connective tissue. In addition, one animal was found dead on the banks of the Yarra River with a hook embedded in its lower bill, two died after becoming hooked on baited lines left unattended overnight (in the Rubicon and Wonnangatta Rivers) and four drowned after fishing line attached to a hook embedded in either a front foot (*n* = 3) or bill (*n* = 1) became tangled in submerged woody debris (in Lake Elizabeth, Mount Emu Creek and the Howqua and Murray Rivers).

Litter

Seven Platypus mortality reports (6% of the total) described animals dying after litter other than fishing line became wrapped around their body or limbs. One animal apparently drowned after its front and back legs on one side became shackled together by a twisted plastic six-pack holder (Serena and Williams 1998). The remaining cases involved loops of litter wrapped around the neck (*n* = 4) or bandolier-fashion from just in front of one shoulder to behind the opposite front leg (*n* = 2), causing deep lesions to develop. The items included a knotted loop of string, a child's plastic bracelet, a plastic cable-tie (circumference = 19.2 mm), and three

plastic rings or loops (in each case, 2-3 mm thick) of unknown origin.

Floods

Five Platypus mortality reports (4% of the total) involved carcasses (two juveniles, three adults or subadults) discovered in the immediate aftermath of major flooding along the Werribee, Yarra, Ovens, Kiewa and Tanjil Rivers.

The fact that juveniles are weaker and less experienced swimmers as compared to older animals suggests that they are more likely to die in floods, particularly if these occur around the time they first emerge from the nesting burrow in late January to February (Grant *et al.* 1983). This hypothesis is supported by the results of Platypus live-trapping surveys carried out in the Melbourne area after more than 120 mm of rain fell on the city in less than 24 hours in early February 2005 (the highest one-day total since weather records began to be kept in 1855). The mean juvenile capture rate from February to June 2005 along Diamond, Mullum Mullum, Olinda and Monbulk Creeks and the lower reaches of the Plenty River was 0.02 animals per site per night, or less than 10% of the corresponding mean capture rate from 2001-2004 (0.25 ± 0.10 , mean \pm S.D.). In contrast, the capture rate for adults and subadults occupying the same five water bodies from February to June 2005 (0.38) was actually slightly higher than the corresponding mean capture rate from 2001-2004 (0.34 ± 0.14 , mean \pm S.D.). Juvenile recruitment appeared to recover in the following year, based on a mean capture rate of 0.20 juveniles per site per night recorded along the five water bodies from February to June 2006.

Road trauma

Five mortality reports involved animals being run over by motor vehicles. Two incidents occurred in the 1990s next to bridge culverts (located along the Watts River at Healesville and Happy Valley Creek at Myrtleford); the person reporting the Myrtleford mortality noted that other Platypus carcasses had been observed at the same location in previous years 'when the creek was running high'. In addition, a Platypus of unknown sex and age died in 2002 during a period of severe drought on a road near Rossbridge (in the Hopkins River catchment), a juvenile female was found dead in 2002 on a road located about 20 m from a

drainage channel near Trafalgar (in the Moe River catchment), and a subadult male died in 2000 after being run over on a private driveway located near Monbulk Creek in Belgrave.

Attack by humans

Four Platypus mortality reports described animals dying after being targeted by humans. One incident involved an animal being shot by a man hunting rabbits along the Barwon River in the 1990s, after he saw bubbles rising in the water. Three other incidents involved animals (presumably unwary juveniles) being bludgeoned to death in shallow water by children or older youths armed with rocks or lumps of wood along Diamond Creek (Yarra River catchment) in the mid-1990s, the Campaspe River in 2003 and Broken Creek in 2004.

Drought

Three mortality reports described a Platypus being found dead (and not apparently killed by a predator) in or near a recently evaporated pool during a period of drought (in the Ovens River catchment in 2003, the Campaspe River catchment in 2004 and the Hopkins River catchment in 2006). These deaths presumably reflect the fact that Platypus are adapted to feed exclusively in the water and starve to death in the absence of adequate surface moisture.

Miscellaneous mortalities

One Platypus drowned in the mid-1990s in a bath tub used to water livestock (the smooth enamel surface apparently making it impossible for the animal to escape). In addition, two very young juveniles died in captivity in 2007 after being inadvertently unearthed from a nesting burrow by a large mechanical excavator working near a pumping station.

Discussion

Nearly three-quarters (74%) of cases where Platypus have been found dead in Victoria since 1980 (and the cause of death could be reliably identified) were linked directly to human activities or behaviour. Our sample almost certainly underestimated 'natural' sources of mortality such as predation, drought or flooding (for example, many victims of predators are presumably consumed entirely, and deaths related to drought are difficult to assign (or even record) if victims die of starvation in burrows or abandon isolated

pools in search of larger water bodies). By the same token, our study only identifies factors implicated in direct mortality; the effects of environmental degradation, introduced species such as Carp (*Cyprinus carpio*) and modified flow regimes in reducing the Platypus's food supply or the extent of its habitat are not addressed. Nonetheless, our results suggest that Platypus survival rates may improve in at least some localities if the following human activities can be curtailed.

Use of illegal fishing nets, yabby/cray traps and fishing lines left unattended overnight

More than half of the deaths described in our records resulted from illegal use of set lines, drum nets, gill nets or (particularly since 2000) fyke nets and enclosed yabby or cray traps. We are particularly concerned that the incidence of Platypus deaths in opera house nets and other forms of enclosed yabby/cray traps appears to have escalated since 2000, even though it has been illegal since mid-2001 to use or possess such traps 'in, on or next to all Victorian inland public waters' (DPI 2009/2010: 66). Opera house nets and other enclosed frame traps can still be set legally in privately owned off-stream dams and ponds and are accordingly widely available for sale throughout the state. In 2009, industry sources estimated that around 100 000 opera house nets are purchased annually in Australia (B Doyle-Cox and B Parsons, pers. comm.). Based on these facts, we predict that enclosed yabby/cray traps will continue to be widely deployed in streams and rivers (and so will continue to drown Platypus and other wildlife) until such a time as their use is outlawed entirely. Safe alternative methods for the recreational harvesting of yabbies and crays are available in the form of baited lines, dip nets and collapsible hoop (or lift) nets.

Use of pumps and hydro-power turbines with entry points accessible to Platypus

A surprisingly high number (8%) of individual mortalities were due to a Platypus being killed after entering an irrigation pump or (in one case) a small-scale hydroelectric turbine. Fitting appropriately designed wire mesh guards or the equivalent around the entry points to all pumps and turbines would benefit landowners by reducing the incidence of blocked pumps as well as help to protect wildlife.

Allowing harmful litter to accumulate in the environment

Ten records described Platypus dying as a by-product of becoming tangled in abandoned fishing line or other forms of litter. The recommendations outlined in Serena and Williams (1998) remain relevant: efforts by individuals or organisations to remove litter from the environment should be strongly encouraged, and everyone should make it their habit to cut through discarded loops or rings of any size (including such seemingly innocuous items as loops of twine, elastic hair ties, engine gaskets or the tamper-proof sealing rings found around food or beverage containers) before disposing of them in a responsible manner.

Inappropriate angling practices

Five records described a Platypus being found dead with a fishing hook embedded in its bill or the webbing of a front foot. Whenever possible, anglers are urged to move a short distance upstream or downstream of a Platypus seen swimming in the vicinity, to reduce the likelihood that the animal becomes inadvertently snagged on a hook. If a hook does become lodged in a foot or bill, the line should not be cut. Instead, the animal should be reeled in gently and the hook removed before the Platypus is released (taking great care to avoid the animal's spurs in the case of adult males).

Acknowledgements

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One hundred years ago

EXCURSION TO WEST WARBURTON

A.D. Hardy

Crossing the Yarra by a substantial bridge, we found a somewhat steep road, mostly formed by side-cutting, leading up the mountain side. Down below ran the Dee, a foaming, rushing rivulet, so embowered in vegetation as to be scarcely visible. Stately tree-ferns, many very tall, with fine specimens of the King fern, *Osmunda Barbara*, took advantage of the cool, sheltered position, and enhanced the scene with their ever graceful fronds. The climbers *Lyonsia* and *Tecoma* entwined the blackwoods, prostantheras and dogwoods, and at every turn some fresh arrangement of foliage delighted the eye. At length we reached a plateau, where had formerly been a sawmill, and, getting directions from a resident, started along a disused timber-tram towards the Rock, which we had decided was to be our goal for the day. The first evergreen Beech, *Fagus Cunninghamii*, was encountered at an altitude of 1,000 feet, and to this height the proscribed *Rubus* has gained a footing along the roadway. The mountain side has been selected and denuded of timber. This belt is about two miles wide. Above it the forest area has also been cleared, partly by legitimate cutting and partly by bush fires. Many years ago the wastefulness of the timber-getter was, in the midst of plenty, and under an old system, hardly observable, but from the standpoint of the system of the last few years, and with timber fast disappearing, the thousands of whitened trunks which lie where they fell, or slid to when cut, caused us to indulge in much useless regret. To-day active watchful foresters traverse the timber lands to check illicit cutting and grazing, and, among much else, even examine the refuse heaps, at the mills to see that every available foot of the logs is made use of, hence waste is now almost reduced to its minimum. When climbing about these mountain sides, forcing one's way through almost impenetrable scrub and over huge tree trunks, one realizes far better than from the comfort of an easy chair the area to be covered, the difficulties of travel—often by saddle impracticable—and the comparative fewness of the officers for the purpose.

From *The Victorian Naturalist* XXVI, pp. 186-187, April, 1910

Identifying germination cues for seven Basalt Plains grassland species prior to their use in a field sowing

Paul Gibson-Roy¹, John Delpratt² and Greg Moore²

¹ Grassy Groundcover Research Project partnered by Greening Australia Victoria and The University of Melbourne, 500 Yarra Boulevard, Richmond, Victoria 3121. Email: roypg@unimelb.edu.au

² School of Land and Environment, The University of Melbourne, 500 Yarra Boulevard, Richmond, Victoria 3121. Email: jdelprat@unimelb.edu.au; gmoore@unimelb.edu.au

Abstract

Germination characteristics of seven indigenous grassland species from the Victorian (Western) Basalt Plains (*Austrodanthonia racemosa*, *Bulbine bulbosa*, *Chrysocephalum apiculatum*, *Leptorhynchus squamatus*, *Leucochrysium albicans* ssp. *albicans* var. *tricolor*, *Linum marginale*, *Wahlenbergia stricta*) were investigated prior to their use in a seeding program. Germination tests at 20°/10°C and 12hr/12 hr light/dark showed a range of maximum germination responses from 21% (*W. stricta*) to 83% (*A. racemosa*). Two trends were observed in terms of speed of germination. *Austrodanthonia racemosa*, *Chrysocephalum apiculatum* and *Linum marginale* germinated rapidly (t_{50} < 7 and 14 days) and *Bulbine bulbosa*, *Leptorhynchus squamatus*, *Leucochrysium albicans* ssp. *albicans* var. *tricolor* and *Wahlenbergia stricta* exhibited a slower germination response (t_{50} between 20 and 30 days). When seeds of each species were exposed to smoke product, cool stratification and smoke cool + stratification, *Linum marginale* was the only species to respond with significantly higher germination (smoke application). Further testing of smoke product at recommended and higher rates produced a range of species-specific dose responses, both positive and negative. These findings confirmed considerable species-specific variations in responses, and differences/similarities of responses between ours and other studies. Therefore, to most accurately gauge seed-lot characteristics, it is recommended that species are routinely tested prior to their use in grassland restoration programs. (*The Victorian Naturalist* 127 (5) 2010, 184–191).

Keywords: grassland restoration, seed germination, seed testing, smoke, direct-seeding

Introduction

The Basalt Plains grasslands of south-western Victoria are a sub-set of the larger Australian south-eastern lowland temperate grasslands. They currently exist as small and fragmented remnants distributed over an area of approximately 23 000 km² of flat and undulating lands (approximately 1% of their original range). These grassy communities are listed as threatened under the *Victorian Flora and Fauna Guarantee Act* (1988) and the *Commonwealth Environment Protection and Biodiversity Conservation Act* (1999). They also have been recognised by the Federal Government's Threatened Species Scientific Committee as one of 15 national biodiversity 'hotspots'.

Basalt Plains grasslands are a diverse flora characterised by tussock grasses, primarily Kangaroo grass *Themeda triandra*, Wallaby grass *Austrodanthonia* sp. and Spear grass *Austrostipa* sp., with a wide variety of native forbs and both annual and perennial exotic species (grasses and forbs) occupying the inter-tussock spaces. A variety of other organisms from different trophic levels contribute to their func-

tion and stability, including mosses, lichens, liverworts and algae (that form cryptogamic crusts on soil surfaces), soil-inhabiting arbuscular mycorrhizal fungi, invertebrate species and a host of vertebrates, reptiles, birds and mammals.

Initial attempts to restore or reconstruct these grasslands were primarily undertaken through the re-introduction of container grown plant material (Hitchmough 1994; Morgan 1999). However, direct seeding has increasingly become the focus of investigation and implementation as a restoration technique (Morgan *et al.* 1993; Huxtable and Whalley 1999; Gibson-Roy 2005; Gibson-Roy *et al.* 2007b). There are constraints with both methods on the availability and knowledge relating to the quality of seed from a broad range of grassland species (Huxtable and Whalley 1999; Mortlock 2000; Gibson-Roy and Delpratt 2006).

Where available, seed resources must be used efficiently (whether for propagation or for direct seeding). To this end, restorationists require information about seed-lot quality and

the germination characteristics of the species to be used (Gardiner and Midgley 1994; Delpratt 1996). Earlier formal studies examining simulated environmental cues have revealed a range of responses by species from this flora to diurnal light, stratification, smoke, fluctuating temperatures, storage environments and storage periods (Willis and Groves 1991; Morgan and Lunt 1994; Dixon *et al.* 1995; Morgan 1998; Bell 1999; Clarke *et al.* 2000; Gibson-Roy *et al.* 2007a). In practice, grassland seed is seldom tested for quality prior to its use in restoration programs, potentially limiting the success and/or interpretation of outcomes (Gibson-Roy and Delpratt 2006).

The aim of this study was to test the response of seven grassland species to a range of simulated germination cues for an indication of possible field responses. Seed testing sought to establish the germination response of each species when exposed to:

- projected autumn temperatures;
- cool-stratification and autumn temperatures;
- plant derived smoke (at various rates).

Methods

Seven indigenous grassland species (*Austrodanthonia racemosa*, *Bulbine bulbosa*, *Leptorhynchos squamatus*, *Chrysocephalum apiculatum*, *Leucochrysum albicans* ssp. *albicans* var. *tricolor*, *Linum marginale*, *Wahlenbergia stricta*) representing a range of functional groups from the Victorian (Western) Basalt Plains grassland community (C3 Grass, Geophyte, Hemicyptophyte, Chamaephyte) were selected for a seedling project. Seed was sourced from roadside populations occurring on basaltic soils near Cressy in Victoria's South West in spring and summer. Seed from two species was sourced from production crops grown at Burnley College. After harvest, seed-lots were dried and stored in paper bags at room temperature until testing (and subsequent sowing in the following autumn).

Germination test

All seed lots were cleaned by removing unattached inert matter. Based on the appearance of individual propagules, seed-lots were then sampled for filled and unfilled seeds. To determine if plumpness was a reliable indicator of the presence of an embryo, sub-samples of 100 seeds from each species were randomly chosen for inspection and dissection under a binocu-

lar microscope (Olympus SZ x 20). Dissection confirmed that visual assessment was a reliable predictor of filled seed.

For testing, six replicates of 25 filled seeds (of each species) were sampled. Seeds were placed on white absorbent paper laid over towelling moistened with deionised water within lidded rectangular plastic trays (210 mm x 310 mm x 30 mm). One tray per species was placed into a germination cabinet set to alternating day/night temperatures of 20°C/10°C, with 12 hr light (supplied by four high voltage fluorescent tubes and four incandescent lights) and 12 hr dark during each 24 hr period. Each tray was inspected at four-day intervals for 43 days. All trays were rotated after each count to spread the effect of any variations in light intensity and temperature within the cabinet. No fungicides were applied to the seeds during the germination test.

Germination was recorded as the emergence of a radicle. Germinated seeds were removed after each inspection. For each species, the following germination characteristics were determined:

- percentage germination after 20 days (G_{20}) and 43 days (G_{43});
- percentage increase in germination from day 20 to day 43;
- time elapsed (lag) between the start of the test (imbibition) and the first germination. Species were grouped into the following lag responses: <7 days, 7-14 days, 15-28 days, >28 days;
- time elapsed between imbibition and 50% of final germination (t_{50}). Species were grouped into the following t_{50} responses: <7 days, 7-14 days, 15-28 days, >28 days.

Glasshouse Experiment 1. Effects of cool stratification and smoke on seedling emergence

A glasshouse experiment investigated the effect of cool stratification and the application of commercial smoke vermiculite (Grayson Regen 2000® Seed Germinator) on the emergence of seedlings of each species. The experimental units were 340 mm x 320 mm black plastic seedling trays. In each tray, the seeds of all species were sown in rows at 40 mm intervals onto a pine bark propagation medium. Sown seeds were covered with either medium grade vermiculite or a blend of medium grade vermiculite and Grayson Regen 2000® Seed Germinator smoke vermiculite (of similar particle

size). The position of species within each tray was randomly allocated. The sowing density for each species was dictated by propagule morphology and size. If seeds were easily cleaned and counted to individuals, 25 seeds were sown in each row. If protective or dispersal coverings made it difficult to isolate individual seeds, a known mass was sown in each row to achieve a target sowing of approximately 25 propagules. Treatments were applied to trays randomly and each treatment was replicated four times. Trays were placed on a glasshouse bench in four randomised blocks. All trays were watered twice daily during the study period. The number of seedlings was recorded weekly for 89 days. Seedlings were not removed after emergence.

The following experimental treatments were imposed.

1. Control:- sown tray lightly covered with 200 mL of vermiculite.
2. Cool stratification:- sown tray lightly covered with 200 mL of vermiculite, watered and placed into a cool room at approximately 4°C for 14 days prior to transfer to the glasshouse.
3. Smoke:- sown tray covered with a blend of 140 mL of vermiculite and 60 mL of Grayson Regen 2000® Seed Germinator smoke vermiculite.
4. Cool stratification + smoke:- sown seed prepared as per the smoke treatment; trays were placed into a cool room at approximately 4°C for 14 days prior to transfer to the glasshouse.

Glasshouse Experiment 2. Effects of differing formulations and rates of application of smoke vermiculite

This experiment investigated the effect of differing application rates of the commercial smoke products Grayson Regen 2000® Seed Germinator smoke vermiculite and Grayson Regen 2000® Seedstarter smoke vermiculite on the emergence of seedlings of each species.

The seed for this experiment was prepared in the manner described for the Glasshouse Experiment 1. Each experimental unit was a 100 x 100 mm black plastic propagation tray. Seeds were sown onto a pine bark propagation medium at the rates described in Glasshouse Experiment 1. Experimental units were randomly allocated within three replicate blocks on a bench in an unheated glasshouse. All containers were watered automatically twice daily. The number

of seedlings was recorded weekly for 89 days. Seedlings were not removed after emergence.

The following experimental treatments were imposed.

1. Control:- no smoke product.
2. Smoke concentration 1:- Grayson Regen 2000® Germinator @ 600 mL m⁻² (manufacturer's recommended application rate).
3. Smoke concentration 2:- Grayson Regen 2000® Seedstarter @ 18 mL m⁻² (equivalent to application rate in Treatment 2).
4. Smoke concentration 3:- Grayson Regen 2000® Seedstarter at 180 mL m⁻² (ten times the smoke product concentration of Treatments 1 and 2).

The data for each study were tested for normality using Ryan-Joiner and, where required, log transformed to satisfy heterogeneity of variance. Differences were compared using ANOVAs with the statistical software Minitab 15.1.

Results

Germination test

Germination occurred for all seven species. However, there were differences between species in the speed of germination and in the final germination percentage (Fig. 1). At day 43 *Austrodanthonia racemosa* and *Chrysocephalum apiculatum* exhibited the highest germination figures (>80%), while *Wahlenbergia stricta* recorded the lowest germination (21%). *A. racemosa*, *C. apiculatum* and *Linum marginale* germinated quickly, reaching between 40% and 60% germination within 5 to 10 days of imbibition. Conversely, although *Bulbine bulbosa*, *Leptorhynchus squamatus* and *Leucochrysum albicans* began to germinate within 10 days of imbibition, each reached less than 10% by day 15. *Wahlenbergia stricta* germinated from day 16 but total germination reached only 21% by day 43. Four species, *B. bulbosa*, *Leptorhynchus squamatus*, *Leucochrysum albicans* and *W. stricta* showed significant (>100%) increases in germination between days 20 and 43. However, of these species only *Leucochrysum albicans* achieved final germination greater than 50% (Table 1).

Glasshouse experiment 1. Effects of stratification and smoke

All species germinated under the experimental treatments. Only *Linum marginale* exhibited significantly increased emergence in response to any treatment. For that species, the stratifica-

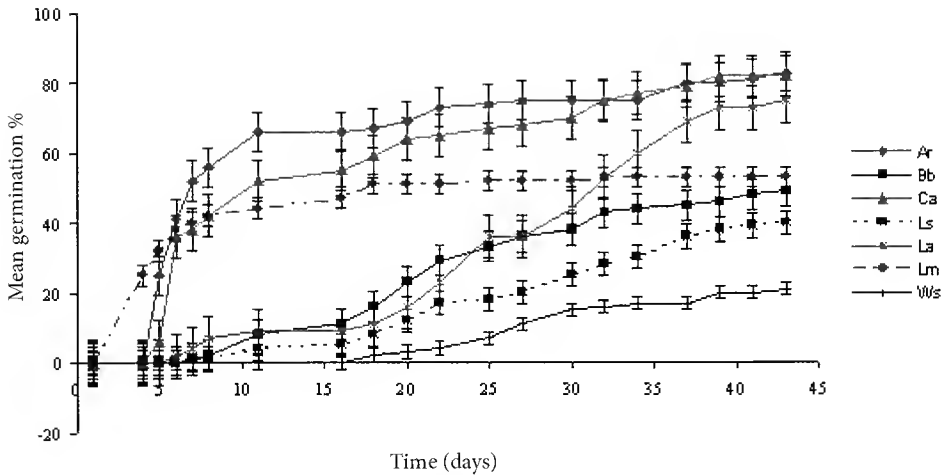


Fig. 1. Mean germination (\pm SE) of seven grassland species over 43 days under cabinet conditions of alternating temperature ($20^{\circ}/10^{\circ}\text{C}$) and light (12 hr/light 12 hr/dark). Ar = *Austrodanthonia racemosa*; Bb = *Bulbine bulbosa*; Ca = *Chrysocephalum apiculatum*; Ls = *Leptorhynchos squamatus*; La = *Leucochrysum albicans* spp. *albicans* var. *tricolor*; Lm = *Linum marginale*; Ws = *Wahlenbergia stricta*.

tion (11^{b}), smoke + stratification (15^{b}) and the smoke treatment (23^{c}) gave enhanced emergence ($p < 0.05$) over the control treatment (5^{a}). However, the smoke and the stratification + smoke treatments resulted in the highest germination.

Glasshouse Experiment 2. Effects of differing formulations and rates of application of smoke vermiculite

Except for *Wahlenbergia stricta*, seedlings of all species emerged during this experiment (Table 2). For emerging species, results were similar in treatments common to this experiment and Glasshouse Experiment 1. There was also close agreement between the results for treatments that compared the two formulations of smoke vermiculite when they were applied at the rate recommended by the manufacturer. As was the case in Glasshouse Experiment 1, only *Linum marginale* responded positively to the smoke products at recommended rate (Regen 2000[®] Germinator - 600 mL m^{-2} and Regen 2000[®] Seedstarter - 18 mL m^{-2}).

The application of smoke product at 10 times the recommended rate (Grayson Regen 2000[®] Seedstarter - 180 mL m^{-2}) significantly reduced the number of seedlings of *Austrodanthonia racemosa*, *Chrysocephalum apiculatum*, *Leu-*

cochrysum albicans and *Linum marginale* ($p < 0.05$). There was no significant effect on seedling numbers of *Leptorhynchos squamatus*. The number of seedlings of *Bulbine bulbosa* increased significantly in trays treated with this higher rate of Grayson Regen 2000[®] Seedstarter ($p < 0.05$).

Discussion

The restoration of threatened grassland communities will require access to, and knowledge of, a scarce seed resource. The seven species examined in this study are representatives from this florally diverse community and each is likely to be included in restoration programs. The tests conducted in this study revealed a range of species-specific responses to temperature and smoke cues that may guide plant propagators and restorationists undertaking propagation and seeding programs.

Germination cabinet testing

All seven species were germinable under a simulated autumn/spring $20^{\circ}/10^{\circ}\text{C}$ temperature regime. Species-specific responses were highlighted through differences in speed of germination and the final germination percentage. These observations are consistent with the findings of McIntyre (1990), Morgan and Lunt (1994), Morgan (1998), and Gibson-Roy *et*

Table 1. Germination responses of seven grassland species at day 43 under alternating temperature (20°/10°C) and light (12 hr light/12 hr dark). G_{20} = mean % germination after 20 days; G_{43} = mean % germination after 43 days; G_{20-43} = % increase in germination from day 20 to day 43; LAG (days) = days elapsed between imbibition and first germination; t_{50} (days) = days elapsed between imbibition and 50% of final germination.

Genus/Species	G_{20} (%)	G_{43} (%)	G_{20-43} (%)	LAG (days)	t_{50} (days)
<i>Austroanthonia racemosa</i>	69	83	20	<7	<7
<i>Bulbine bulbosa</i>	23	49	113	7-14	15-28
<i>Chrysocephalum apiculatum</i>	64	82	28	<7	7-14
<i>Leptorhynchus squamatus</i>	12	40	233	7-14	15-28
<i>Leucochrysum albicans</i>	16	75	369	<7	15-28
<i>Linum marginale</i>	51	53	4	<7	<7
<i>Wahlenbergia stricta</i>	3	21	600	7-14	15-28

Table 2. Mean seedling numbers (Standard Deviation) at the completion of the Glasshouse Study 2 imposing differing rates of smoke vermiculite. Control = no application of smoke vermiculite; smoke 1 = Grayson Regen 2000® Germinator @ 600 mL m⁻²; smoke 2 = Grayson Regen 2000® Seedstarter @ 18 mL m⁻²; smoke 2 (high) = Grayson Regen 2000® Seedstrater @ 180 mL m⁻². Different letters indicate significant differences within rows following One-Way ANOVA ($p < 0.05$). ns = not significant.

Genus/Species	Control	Smoke 1	Smoke 2	Smoke 2 (high)
<i>Austroanthonia racemosa</i>	37 ^b (1.5)	38 ^b (4.6)	36 ^b (1.8)	10 ^a (3.0)
<i>Bulbine bulbosa</i>	5 ^a (1.5)	10 ^b (0.3)	7 ^a (2.5)	15 ^b (1.5)
<i>Chrysocephalum apiculatum</i>	40 ^b (13.5)	62 ^b (14.6)	54 ^b (7.1)	21 ^a (7.5)
<i>Leptorhynchus squamatus</i>	20 ^{ns} (9.0)	18 ^{ns} (3.5)	14 ^{ns} (1.0)	11 ^{ns} (2.5)
<i>Leucochrysum albicans</i>	23 ^c (0.8)	18 ^{bc} (0.5)	16 ^b (2.5)	11 ^a (2.5)
<i>Linum marginale</i>	8 ^b (0.2)	18 ^c (0.7)	16 ^c (1.1)	1 ^a (0.5)
<i>Wahlenbergia stricta</i>	0	0	0	0

al. (2007a). It is unlikely that any single set of temperature and/or light regimes will provide optimal germination conditions for a broad selection of grassland species. This is an important issue for field sowings of complex species mixes. It is unrealistic to expect rapid and synchronous emergence of all species under any combination of field conditions.

In general, the species exhibited two patterns in terms of the speed at which germination occurred. One group (*Austroanthonia racemosa*, *Chrysocephalum apiculatum*, *Leucochrysum albicans*, *Linum marginale*) began to germinate rapidly (lag < 7 days). The second group (*Bulbine bulbosa*, *Leptorhynchus squamatus* and *Wahlenbergia stricta*) were slower to germinate (lag 7-14 days). These responses are consistent with results reported by Morgan (1998), who found that *C. apiculatum* and *Leucochrysum albicans* had lag times of < 7 days, *Leptorhynchus squamatus* a lag of 7-14 days and that *B. bulbosa* exhibited a lag of 14-28 days.

Interestingly, a short lag period did not always result in a high final germination percentage. For example, *Linum marginale* germinated

rapidly until day seven (40%), after which little further germination occurred (53% at day 43). This is a commonly observed pattern in recently-harvested seed of this species (John Delpratt unpub. data). Conversely, there were few germinants of *Leucochrysum albicans* up to day 15 (10%), after which germination increased rapidly, reaching 75% by day 43. However, we are aware that the lag (and t_{50}) period for *Leucochrysum albicans* reduces to a few days following longer periods of dry storage (> 3 months) (Gibson-Roy and Delpratt, unpub. data).

Comparison of our results with those of similar studies indicates that testing of the same species can result in both similarities and differences in germination responses. For example, final percentage germination for *Austroanthonia racemosa* was (G_{43}) 83%. This is similar to Gibson-Roy *et al.* (2007a) (G_{28} 95%). *C. apiculatum* (G_{43} 82%) was similar to Morgan (1998) (G_{56} 87%), and Willis and Groves (1991) (G_{60} 94%). Conversely, *Leptorhynchus squamatus* (G_{43} 40%) exhibited a higher germination percentage than reported by Morgan (1998) (G_{56} 20%) and Gibson-Roy *et al.* (2007a) (G_{28}

16%), as did *W. stricta* (G_{43} 21%) compared to Willis and Groves (1991) report of 0% germination after 60 days. Our finding of 49% (G_{43}) germination for *B. bulbosa* was lower than Morgan (1998) (G_{56} 74%), but higher than that reported by Gibson-Roy *et al.* (2007a) (G_{28} 14%). These differences in germination responses between tests and studies can result from differences in maternal conditions, seed collection techniques, cleaning and storage techniques, cabinet environments and observation periods. This confirms that the testing of seed-lots prior to their use in restoration programs will give a more accurate indication of germinability than will historical information for that species.

Glasshouse experiments

Cool stratification and smoke

Dixon *et al.* (1995) reported that the germination of many Western Australian species could be promoted by the application of plant-derived smoke. Since then, a number of other studies have reported varying responses to smoke cues across a broad range of Australian forest and understorey species (Roche *et al.* 1997; Tieu *et al.* 1999; Clarke *et al.* 2000; Lloyd *et al.* 2000; Merritt *et al.* 2006; Thomas *et al.* 2007). Such studies indicate that while a number of species show a positive response to smoke derivatives, many others exhibit no, or only a small, response to smoke or smoke derivatives under laboratory or glasshouse conditions (Clarke *et al.* 2000; Merritt *et al.* 2007).

In Glasshouse Experiment 1, the emergence of *Linum marginale* was significantly enhanced above that of the control treatment (20%), using smoke vermiculite, cool stratification and a combination of smoke vermiculite and cool stratification. However, the smoke treatment on its own resulted in significantly higher emergence (92%) than smoke + stratification (60%) and the stratification (44%). This information, coupled with the lack of evidence for any serious inhibition of the other species, suggests that the application of smoke might be considered when propagating this species.

For the other species, neither smoke application, cool stratification, nor a combination of both, resulted in enhanced seedling emergence above that of a control treatment. Again, these responses are not always consistent with findings from earlier testing. For example, Clarke *et al.* (2000) reported lower emergence of *Bulbine bulbosa* and *Leucochrysum albicans* after seed

had been exposed to cool stratification. In the case of *L. albicans*, Willis and Groves (1991) found it had the effect of increasing germination. Our findings suggest that cool stratification prior to propagation or seeding would not enhance germination or emergence of these six grassland species.

In Glasshouse Experiment 2, we tested the effects of smoke products at recommended and higher rates. As was expected, we observed a significant enhancement of germination over the control treatment for *L. marginale* using recommended rates of Grayson Regen 2000® Germinator (600 mL m⁻²) and Grayson Regen 2000® Seedstarter (18 mL m⁻²) treatments. This confirmed the finding of Glasshouse Experiment 1 and further indicates that the germination of this species can be stimulated by the application of either of these commercial formulations (at recommended rates). Interestingly, *Wahlenbergia stricta* failed to emerge under any treatment. The reason is not clear as seeds from the same seed-lot germinated/emerged (albeit at low rates) in the other two experiments and in subsequent field experiments (Gibson-Roy 2000). It is possible that the dormancy status of seed from this species had increased by the time of this experiment, suggesting that this species may experience dormancy cycling (Baskin and Baskin 1998).

Consistent with Glasshouse Experiment 1, other than *Linum marginale*, our species did not respond significantly to smoke at the recommended application rates (both Grayson Regen 2000® Germinator and Grayson Regen 2000® Seedstarter). However, when compared to the control treatment, emergence of *Leucochrysum albicans* tended to reduce with increasing concentrations of smoke product, becoming increasingly significant with increasing rates of Grayson Regen 2000® Seedstarter. Drewes *et al.* (1995) reported that exposure to smoke product (smoke water) at high concentrations was inhibitory to lettuce germination. Observations from our study also suggest that there is a potential to both inhibit and promote the emergence of plant species using higher rates of smoke products. For example, the reduction in emergence of *Austrodanthonia racemosa*, *Chrysocephalum apiculatum*, *Leucochrysum albicans* and *Linum marginale*, and the promotion of *Bulbine bulbosa* at the 180 mL m⁻² application rate (Grayson Regen 2000® Seedstarter)

clearly demonstrate a concentration response to plant-derived smoke. This observation is of relevance to propagators and restorationists, and suggests when using commercial smoke products that care should be taken to establish the most efficacious rates.

The type of smoke formulation used in this study (smoke vermiculite) will be of interest to nursery propagators (Grayson Regen 2000[®] Germinator) and restorationists (Grayson Regen 2000[®] Seedstarter) where it can be demonstrated that particular species respond to smoke. Both commercial formulations are relatively simple to handle and apply and their use in both the nursery and the field may enhance seedling emergence. A minor reservation about the use of Regen 2000[®] Germinator for nursery seedling propagation is that its recommended rate of application does not provide sufficient cover on a seedling tray to produce the other benefits of vermiculite sought by the propagator. For this reason, the volume of vermiculite applied in these experiments was increased with untreated vermiculite of a similar particle size.

Also, under field conditions the potential for plant-derived smoke to stimulate the germination of weed species must be considered. In a study of smoke effects on soil seed bank germination from eucalypt forest in the Hunter Valley of New South Wales, Read *et al.* (2000) found that germination enhancement was not limited to native species. They reported that while a number of native species responded positively to plant derived smoke, four weed species (one annual and three perennials) were also stimulated.

Karrikinolide (the butenolide 3-methyl-2Hfuro[2,3-c]pyran-2-one, KAR₁) has been identified as a germination-active chemical present in smoke (Flematti *et al.* 2004; Chiwocha *et al.* 2009). Identification of this molecule has allowed various research groups to conduct more precise germination experiments using known concentrations of this chemical (Merritt *et al.* 2006). However, the commercialisation of karrikinolide as a product is believed to be some time off (D Merritt pers. com. 2009). In the meantime, testing smoke responses in both indigenous and non-indigenous species using plant derived smoke is important. However, the lack of products that contain known and controllable concentrations of a specific active

ingredient will continue to limit the interpretation of results of experiments using generic plant-derived smoke.

Implications for grassland restoration

The three experiments reported in this study investigated the germination and emergence responses of seven grassland species exposed to a selection of temperature and smoke cues. These species were then to be included in a seed mix for a subsequent seeding program. It remains unclear whether investigations of this type allow for accurate predictions of seed behaviour under field conditions. However, the range of responses to germination cues, both within and between species, mean that site preparation and post-sowing planning for the field sowing of complex seed mixes must anticipate protracted and asynchronous emergence. Therefore, the results provided a basis for decisions about seed mix composition, species-specific sowing rates and sowing treatments (e.g. sowing season, whether to apply a smoke treatment).

Our findings add to a growing body of information that is improving the efficiency with which limited seed resources are used. They confirm considerable species-specific variations in responses, and differences/similarities of responses between our results and other studies. To better guide nursery and field seeding decisions, we strongly recommend that nursery propagators and field practitioners should test seed-lot characteristics prior to the initiation of a grassland restoration program.

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One hundred years ago

THE UTRICULARIAS. — P von Huetzelburg, in *Flora*, c. (1909) p. 145, gives the results of a study of various species of *Utricularia* and comes to the conclusion that they are truly insectivorous, being able to digest the insects which they catch owing to the secretion of an enzyme and an acid. The hairs which entrap the insects secrete sugar and mucus, but have no digestive action. The bladders are all of similar structure, and the flap closes so tightly, owing to the mucus present, that no insects can possibly get out.

From *The Victorian Naturalist* XXVII, p. 30, June, 1910

The effect of artificial night light on the abundance of nocturnal birds

Marian Weaving^{1,2} and Raylene Cooke¹

¹ Life and Environmental Sciences, Deakin University, Melbourne Campus, Burwood, Victoria 3125

²Corresponding author Email: mweaving@deakin.edu.au

Abstract

Urbanisation is increasing rapidly, impacting on a broad range of species. The proliferation of electric light has transformed the night time environment; however, our understanding on the effects of artificial night lighting on fauna, including nocturnal birds, is extremely limited. The aim of this research was to determine whether artificial night light affected the abundance of nocturnal birds. Spotlighting surveys were undertaken in Research Park, Melbourne, Victoria, along three 300 m transects. Each transect was surveyed five times during three light treatments: when lights were on, 20 minutes after lights were turned off and when lights were absent, over a period of ten nights. A total of 123 nocturnal birds was detected during survey nights. Two species were recorded — the Southern Boobook *Ninox novaeseelandiae* and the Tawny Frogmouth *Podargus strigoides*. The Tawny Frogmouth was detected along all three transects ($n=121$); however, the Southern Boobook was detected along one transect only ($n=2$). None of the light treatments had a significant effect on bird abundance. Neither did location, habitat or the combined effects of light treatments, location and habitat. The results of this research will contribute to a growing body of knowledge and support future conservation activities for species in areas undergoing urbanisation. (*The Victorian Naturalist* 127 (5) 2010, 192-195).

Keywords: Tawny Frogmouth, urbanisation, Southern Boobook

Introduction

The transformation of natural environments to urban use, and the resulting effects on fauna, have been examined widely, including the effects of habitat fragmentation (Antos and White 2004; Parris 2006), human disturbance (Bosakowski *et al.* 1993; Slabbekoorn and Peet 2003), and modification of habitats (Walsh *et al.* 2001; Cooke *et al.* 2006). The impact of artificial night light on nocturnal birds, however, is poorly understood.

The proliferation in both *type* and *use* of electric light has, in recent times, transformed the night environment over a substantial portion of the earth's surface (Longcore and Rich 2004). The implications of this transformation on faunal species is yet to be fully understood (Rich and Longcore 2006).

Longcore and Rich (2004) use the term *light pollution* to describe the degradation of views of the night sky. They also describe artificial light sources that alter the natural patterns of ecosystems as *ecological light pollution*. These include direct glare from temporary, unexpected fluctuations in lighting and increased illumination from sources such as lighted buildings, towers and streetlights.

In natural settings, ecological light pollution has demonstrable effects on both the popula-

tion and behavioural ecology of a range of species. Increased illumination enables some diurnal species to extend their foraging activities into the night time (Zhou *et al.* 1998; Negro and Bustamante 2000). For some nocturnal species, increased illumination enhances prey availability (Blake *et al.* 1994). Conversely, for a number of species, particularly those adapted to navigating in dark environments, the presence of night lighting can be disorienting, resulting in high levels of mortality (Salmon *et al.* 1995; Jones and Francis 2003).

Some species of nocturnal birds are advantaged by increased illumination, either natural or artificial, resulting in increased predation opportunities (Bouskila 1995) and higher levels of hunting success (Clarke 1983). Our understanding of the full range of ecological consequences of artificial night lighting on species, including nocturnal birds, however, is still very limited. As many areas continue to undergo rapid urbanisation, further research is required to ensure that current, and future, conservation activities take into consideration the effects of artificial night light on both diurnal and nocturnal species. The aim of the study is to determine whether artificial night light affects the abundance of nocturnal birds, in three ways:

1. with the presence of artificial night light;
2. in the absence of artificial night light;
3. 20 minutes after artificial night light is turned off.

Methods

Site description

Research Park is located in Research, a suburb within the Shire of Nillumbik, Melbourne, Victoria. The park is approximately 5 ha in size and surrounded by residential development on three of its four sides, with the fourth side bordered by a main road. Park vegetation consists of small pockets of high quality remnant bushland surrounded by parkland containing a high number of weed species. The park is used for a range of recreational purposes and contains a football oval and six tennis courts. Both the oval and tennis courts are lit for night use throughout the year on all weeknights and most weekends, with duration of lighting varying for both.

Lights used by both the football club and tennis courts are metal haloid type and vary between 1000 and 2000 w. All lights are positioned to ensure that glare is directed inwards onto the courts and oval but residual light glare extends approximately 20 m into the surrounding bush and parkland from the outer perimeter of both the oval and the courts.

Survey techniques

Three lines of transect, each of 300 m in length, were located on the outer boundary of the region of light glare along three of the four boundaries of the park. Transect one was located adjacent to three of the six tennis courts in an area containing a number of large living *Eucalyptus* trees. Transect two was located within a strip of high quality remnant bushland and transect three was located in a section of the park containing both living and dead, scattered, large, *Eucalyptus* and *Corymbia* trees.

During August 2007, spotlighting was undertaken along transects and extended into the edge of the oval and tennis courts to survey for nocturnal bird species. Each transect was surveyed five times during nights when: (1) lights were turned on; (2) 20 minutes after the lights were turned off (on the same night) and (3) lights had not been used at all.

During surveys, all species of nocturnal birds detected were recorded by experienced

observers. Survey times differed considerably throughout the research period due mainly to time factors associated with light treatments.

Statistical analysis

Data were analysed with the statistical package SPSS using a multi-factor ANOVA test to determine whether bird abundance was affected by the three light treatments, whether the location of transects and habitat had an effect on abundance levels, and whether there was an interaction between the location of transects and the three light treatments on overall bird species abundance.

Results

A total of 123 nocturnal bird sightings was detected during the ten survey nights. Two species were recorded over the survey period, the Southern Boobook *Ninox novaeseelandiae* and the Tawny Frogmouth *Podargus strigoides* (Table 1.). The Tawny Frogmouth was detected in all three transects ($n=121$); however, the Southern Boobook was detected along only one transect ($n=2$).

None of the light treatments had a significant effect on bird numbers ($F=232$, $df=2,36$, $p>0.05$). The location of, and habitat contained within transects did not have a significant effect on bird numbers ($F=133$, $df=2,36$, $p>0.05$). There was no significant interaction between transect location and the three light treatments on overall bird species abundance ($F=2.105$, $df=4,36$, $p>0.05$) (Fig. 1).

Discussion

Overall, the highest number of sightings was recorded in transect one. This transect also had the highest number of sightings during the 'lights on' and '20 minutes after lights off' treatments. The presence of the artificial light source may have accounted for the high number of sightings detected along transect one. For both the Tawny Frogmouth and Southern Boobook, invertebrates comprise a significant proportion of their diet (Rose and Eldridge 1997; Penck and Queale 2002). Even during cooler survey nights, high numbers of flying invertebrates were observed clustering around the lights at this transect during the lights on period. Artificial light can act as an attractant for invertebrates (Frank 1988), and as a factor influencing invertebrate activity and abundance levels (Kamm 1973; Fordyce *et al.* 2006).

Table 1. Number of birds recorded in transects during all three light treatments (n=123).

Transects	lights on	20 minutes after lights off	Lights absent
1	19	15	9
2	15	12	12
3	10	13	18
Totals	44	40	39

Light-attracted invertebrates have been an important prey source for several species including the Western Burrowing Owl *Athene cucularia hypugea*. Increased prey availability, and enhanced foraging success have been contributing factors to the species' reproductive success in an urban environment (Botelho and Arrowood 1996). The abundance of light-attracted invertebrate prey also has been an important factor in the establishment and the long-term survival of a colony of Lesser Kestrels *Falco naumanni* in a highly urbanised city in Spain (Negro and Bustamante 2000).

Other factors also may have contributed to the high number of nocturnal birds detected at this transect. These include the presence of mature, but not locally indigenous, rough barked *Eucalyptus* species, which Tawny Frogmouths are known to prefer as perching and roosting sites, (Kortner and Geiser 1999), and the proximity of streetlights, which may have encouraged the birds to remain in the area to forage after the focus lighting had been turned off (Hobbs 1961; Rose and Eldridge 1997).

Irrespective of the survey time (sometimes as late as 11 pm), birds were seen actively foraging and changing perch sites in the vegetation

around transect one. During the cooler winter months, when food resources are generally low, Tawny Frogmouths are known to enter torpor as a strategy to conserve energy (Kortner *et al.* 2001). This strategy also occurs in several other caprimulgiform birds. Night torpor bouts in Tawny Frogmouths last, on average, for up to seven hours after a short activity period around dusk and just before sunrise (Kortner *loc. cit.*). The combined effects of additional food resources and increased foraging success may be triggering a delay in the birds' torpor period, enabling them to take full advantage of an increased food resource at a time when resource abundance for these birds is traditionally low.

Transect two recorded the second highest number of birds during the light absent treatment. All birds were located perched in trees on the edge of the remnant closest to the light source, but were not observed hunting for prey at this transect.

The high number of birds recorded along transect three during all three light treatments was unexpected, particularly during the lights absent treatment (n=18). Similar to transect one, factors including bright street lighting and the availability of vegetation for foraging activities, may have contributed to this result.

Research constraints

The results presented here were subject to a range of limitations, including changed lighting times, fluctuating light intensities, space constraints for transects and the short duration of the study, conducted during one month of winter. While not statistically significant, the data and observations from this study indicate that there may be biological importance in the results obtained. Further research is required to determine if these results represent a trend or a random occurrence.

Conclusion

While urbanisation can have negative consequences for many species (Chase and Walsh 2006), there are others that appear to be adapt-

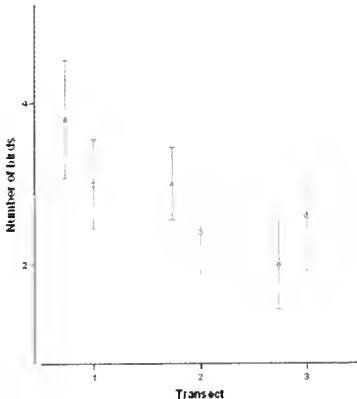


Fig. 1. Number of birds recorded in August 2007 in transects during three light treatments Δ = lights on, ○ = 20 minutes after lights off and □ = light absent.

ing to, and occupying, urban and suburban environments with some success (Low 2002). Urban light sources are a prominent feature of urban environments. Their prey attracting capacity may support the occupation of some species in urban environments.

The presence of the Tawny Frogmouth in Research Park has been noted by the local friends group during surveys over the past decade. Results indicate that numbers appear to remain high and consistent from year to year (Joy Pagon pers. comm. 2007). The Tawny Frogmouth is neither a hollow-dependent species nor reliant on any one particular prey source. (Kortner and Geiser 1999; Kaplan 2007). Generalist habitat requirements combined with an unseasonal and abundant food source may be factors contributing to its continuing occupation of Research Park.

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Storm damage on Black Rock Sea Wall, April 2009

Eric Bird

Geostudies, Australia, 343 Beach Road, Black Rock, Victoria 3193

Abstract

In recent years episodes of storm damage to the sea wall at Black Rock have occurred in April and May, when the adjacent sandy beach has disappeared because of northward longshore drifting during the previous summer. Southward drifting from April to November then restores a protective beach in front of the sea wall. Damage is likely to recur in April and May unless a beach can be artificially maintained in front of the sea wall. (*The Victorian Naturalist* 127 (5) 2010, 196-200).

Keywords: storm damage, sea wall, longshore drift, beach erosion

Introduction

The north-east coast of Port Phillip Bay consists of alternating headlands and sandy bays. The coastal geology consists of a soft pale clayey sandstone, the Red Bluff Sand, over a harder dark brown ferruginous sandrock, the Black Rock Sandstone, both well exposed in Red Bluff (Kenley 1967). The contact between the Red Bluff Sand and the Black Rock Sandstone undulates gently: it protrudes on headlands with rocky shore ledges where it is slightly above mean sea level at Black Rock Point and Quiet Corner, and it is a little below mean sea level along Black Rock Beach, where the dark sand-rock is partly exposed at low tide.

Headlands divide this coast into several natural beach compartments, in each of which sand drifts northward during the summer half-year from November to April (Fig. 1), and southward during the winter half year from May to October (Fig. 2). Black Rock Beach, extending from Black Rock Point south to Quiet Corner, is one of these. By late summer the northern half of the beach has widened, while the southern half is much reduced, and has an extensive beach-less sector (Fig. 1). During the winter half-year, sand drifts southward, so that the northern half of the beach is narrower, and the southern half has a beach extending in front of the sea wall towards Quiet Corner.

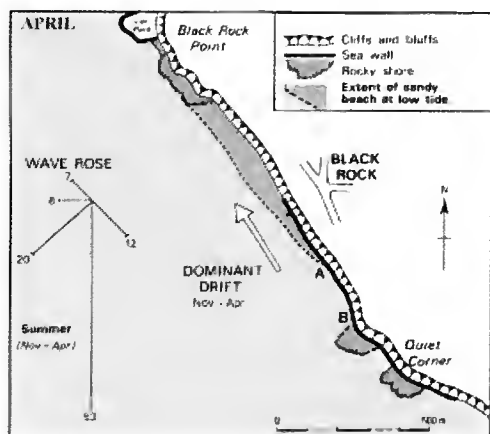


Fig. 1. Black Rock Beach at the end of summer (April) after six months of dominant northward drifting. AB is the sector of sea wall that was not beach-fringed, and was thus damaged during the storm of 25-26 April 2009.

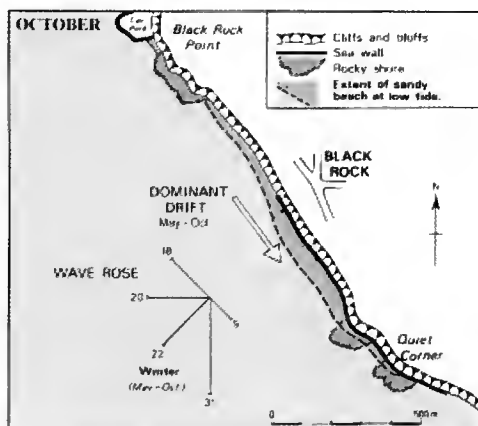


Fig. 2. Black Rock Beach at the end of winter (October) after six months of dominant southward drifting has established a protective beach in front of the sea wall.

The extent of seasonal drifting has varied from year to year. In April 2000, northward drifting during the summer had been so pronounced that the beach disappeared along the whole length of the sea wall and became exceptionally low and narrow in the central sector, near the Black Rock Life Saving Club. In most years a short sector of beach persists in late summer below the Black Rock car park, but invariably it disappears from the sea wall sector between A and B in Fig. 1, which is then exposed to wave attack.

The northern half of Black Rock Beach stands in front of a scrub-covered bluff which was formerly a receding cliff cut in soft Red Bluff Sand, while the southern half was an active, receding cliff when the first European settlers came here in the 19th century. The contrast is probably related to the evolution of the beach system, with a perennial beach of varying width in the northern half, and seasonal exposure to wave action along the southern half, where the cliff was unprotected by a fringing beach for several months each summer.

It has been suggested that cliffs were more extensive around Port Phillip Bay during the early Holocene, between 6000 and 4000 years ago, when sea level was slightly higher than it is now, and that a subsequent fall in sea level (which promoted beach accretion) resulted in their being reduced to steep, vegetated slopes. Cliffs persisted only on exposed sectors, notably headlands (Bird 1993).

A storm surge on 29–30 November 1934 caused extensive erosion along the east coast of Port Phillip Bay, and in the following year the state government set up a Foreshore Erosion Board, which surveyed sectors where erosion had been rapid (Mackenzie 1939). It was decided that sea walls should be built to protect the most vulnerable sectors, including one extending from Black Rock south to beyond Quiet Corner. This was constructed between 1936 and 1939, and took the form of a masonry wall and undercliff walk, the backing cliff being graded to a 30° slope and planted with grasses and shrubs.



Fig. 3. Waves breaking over the sea wall at Quiet Corner on 26 April 2009.



Fig. 4. The 26 April 2009 storm had little effect on the sandy beach north of Black Rock. Seaweed litter marks the limit of storm swash on that day.

The storm of 25-26 April 2009

A deep depression passed across southern Victoria on 25-26 April 2009, generating a south-westerly gale over Port Phillip Bay. For several hours, waves up to 2.5 m high broke heavily on the shore between Black Rock Point and

Quiet Corner (Fig. 3). In the northern half of the Black Rock beach compartment the waves broke on the seaward margin of the wide sandy beach and had little effect, the wave energy being absorbed by the sandy beach (Fig. 4). In the southern half a long sector of the sea wall (AB in Fig. 1) had no protective beach, and this is why the waves caused such severe damage (Fig. 5). Within a few days, southward drifting of sand began to build a beach in front of the damaged sea wall. By the end of May the sea wall was bordered by a narrow protective beach, and during the winter this became wider, until in November the wall was well protected (Fig. 6). Bayside Council decided to repair the sea wall and restore the features that existed prior to the storm, and this work was completed on 20 November.

The storm damage on 25-26 April 2009 was not unprecedented. There had previously been several episodes of storm damage, particularly in April and May, the time when there is little or no beach in front of the sea wall. The storm of 30 April 1986 inflicted similar damage (Fig. 7). The



Fig. 5. Damaged sea wall south of Black Rock, 27 April 2009.



Fig. 6. Protective beach in front of sea wall south of Black Rock, November 2009.

repaired sea wall between A and B on Fig. 1 is still vulnerable to storm damage in early winter, before drifting sand arrives to build a protective beach in front of it.

Sea wall protection

One way of protecting this sea wall would be to dump large boulders in front of it, but this would cause wave reflection and prevent beach accretion (as it did on the Hampton shore in the 1970s). An alternative would be to build an offshore breakwater parallel to the coastline and about 30 m seaward. This would protect the sea wall from storm wave attack and also induce beach accretion along the sea wall, shaped by waves refracted round its ends. Either of these measures would be criticised as introducing unsightly structures to the shore.

Another way of preventing damage to this sea wall would be to form and maintain a protective beach in front of it all year round. When the sea wall was originally constructed, a series of wooden groynes was built, protruding about 20 metres seaward, in the hope of trapping sand and retaining a protective beach, but they were not effective, and soon deteriorated. Only minor remnants can now be seen, for example just north of Quiet Corner.

A previous attempt was made in December 1969 to maintain this beach by dumping numerous lorry-loads of sand in front of the sea wall (Fig. 8), but it all drifted away to the north during the following summer. It might be possible to maintain a beach here by dumping a very large quantity of sand (of the order of 200 000 m³), but there then would be losses northward (round Black Rock Point) when the

beach became very wide in late summer, and southward (round Quiet Corner) when it widened at the southern end in late winter. In due course these losses would deplete the beach, and after a few years the sea wall between A and B would be again exposed to storm waves. An alternative would be frequent renourishment of the AB sector with sand pumped or ferried from the northern end of the beach, but this would be expensive, and such perennial recycling is unlikely to be maintained.

It would be possible to stop sand drifting away northward from the southern half of Black Rock Beach each summer by building large stone groynes at A and B to enclose a compartment containing deposited beach sand (Bird 1990). Such groynes have been successful in retaining artificial beaches at Hampton, and have been introduced (despite some local opposition) on Sandringham beach. It is likely that they would prove successful in maintaining a beach and ensuring stability of the sea wall between Black Rock and Quiet Corner.



Fig. 7. Damage to sea wall by a previous storm, 30 April 1986.



Fig. 8. Sand dumped on the shore near Quiet Corner, December 1969. It drifted away to the north during the next four months, and did not provide winter protection for the sea wall.

This analysis of the storm damage to the Black Rock sea wall illustrates the need for coastal managers and engineers to be aware of geomorphological processes.

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One hundred years ago

SANCTUARIES FOR SEABIRDS

By a recent *Gazette* notice the Tasmanian Government has proclaimed Foster and Albatross Islands as sanctuaries for sea-birds. The former is situated in Banks Strait, off the north-east coast of Tasmania, and is the resort of Pelicans and Cape Barren Geese; while Albatross Island, off the north-west corner of Tasmania, is the breeding place of the Sooty Albatross and other birds. Cat and Storehouse Islands, portion of the Flinders Group, on which there are extensive rookeries of gulls, gannets, penguins, and muttonbirds have also been reserved, so that our sea-birds should now receive some measure of protection, and naturalists should be deeply indebted to the Tasmanian Government for its action.

From *The Victorian Naturalist* XXVII, p. 30, June 9, 1910

Parks — a haven for frogs?

Robin Drury and Graeme Patterson

Fauna Survey Group, Field Naturalists Club of Victoria

Abstract

A frog survey was undertaken in Churchill National and the adjacent Lysterfield State Park in the 12 months beginning May 2008. Frogs were identified by their advertisement calls. Nine species were identified including the state significant Southern Toadlet *Pseudophryne semimarmorata*. The Parks therefore provide habitat for the majority of frogs with known distributions in the region. The survey was undertaken in a period of below average rainfall and a follow-up visit after a heavy rainfall event demonstrated how rainfall is critical to results, when using this survey technique. The follow-up visit found six species at sites where they had not been previously recorded, including one species heard at five additional sites. The survey provided evidence of the suitability of artificial wetlands for frogs. The results showed the need for a survey relying on advertisement calls to cover an annual cycle given the seasonality of frog mating activity. (*The Victorian Naturalist* 127 (5) 2010, 201-204).

Key words: frogs, parks, rainfall, human-constructed wetlands, seasonality

Introduction

Churchill National Park and Lysterfield State Park make up 1668 ha of contiguous reserve, some 35 km south-east of Melbourne. Churchill National Park was proclaimed as such in 1943 and consists of mainly remnant vegetation (Cook 1994), although some has been modified due to a power easement. Quarrying previously took place within its boundaries. The adjacent Lysterfield State Park, once agricultural land, contains a lake that was constructed in 1929 to provide water for domestic and agricultural use to the south (Coulson 1959). To improve water quality, surrounding agricultural land in the lake's catchment was compulsorily acquired in the early 1940s. In the late 1950s, the State Rivers and Water Supply Commission carried out a re-forestation program in the form of eucalypt plantations (Coulson, 1959). Lysterfield Lake was no longer required as a water supply after 1975 when Cardinia reservoir became operational. In 1997, the two parks were joined by the purchase of an area known as the 'link lands'. These link lands, formerly used for farming, are being revegetated gradually with indigenous species.

This survey was carried out to assess frog species richness in the parks. Fourteen wetland sites were selected, to represent both a geographical spread across the parks, and the diversity of wetland types. Six of the sites were in Churchill National Park, two in the link lands and six in Lysterfield Park. All the sites were either totally

human-constructed (lake, dam or channels) or modified in some way (e.g. a track blocking a creek). Both natural and constructed wetlands have previously been shown to support similar numbers of frog species (Hazell *et al.* 2004). All sites contained vegetation or debris in and around the water column.

The parks were visited 11 times (approximately one month apart) in the 12 months beginning May 2008. At each site, frog calls were recorded for five minutes using a JNC USB350 digital recorder and a Yoga EM-2700 video camera microphone. Nine species of frog were identified in the study (Table 1). Findings were submitted to Melbourne Water for inclusion in their frog census. Melbourne Water assisted with the interpretation of calls.

The maximum site species richness was six (at three sites) and the minimum one (Fig. 1). The

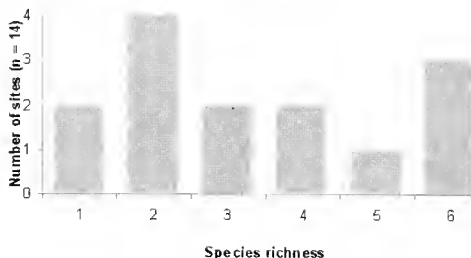


Fig. 1. The frog species richness at the survey sites.

Table 1. The frog species recorded at Churchill National Park and Lysterfield State Park together with the number of sites and nights they were recorded.

Species	Common Name	Number of nights recorded (max 11)	Number of sites recorded (max 14)
<i>Crinia signifera</i>	Eastern Common Froglet	11	12
<i>Geocrinia victoriana</i>	Victorian Smooth Froglet	4	3
<i>Limnodynastes dumerilii</i>	Eastern Pobblebonk	5	7
<i>Limnodynastes peronii</i>	Striped Marsh Frog	2	1
<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog	2	5
<i>Litoria ewingii</i>	Southern Brown Tree Frog	9	10
<i>Litoria peronii</i>	Peron's Tree Frog	3	3
<i>Litoria verreauxii verreauxii</i>	Verreaux's Tree Frog	5	4
<i>Pseudophryne semimarmorata</i>	Southern Toadlet	3	2

two sites where only one species was recorded were the boat ramp at Lysterfield Lake and a channel site that rarely contained water.

The species can be divided into generalist callers, autumn/winter callers and spring/summer callers. This spread highlights the importance of surveying all year round when assessing the frog species in an area.

The generalist callers were *Crinia signifera* (12 sites) and *Litoria ewingii* (10 sites). These species were recorded on most nights and in the majority of locations. The sites at which they were not recorded usually lacked any significant water.

The autumn callers were *Geocrinia victoriana* (3 sites) and *Pseudophryne semimarmorata* (2 sites). *Geocrinia victoriana* was recorded at three heavily wooded sites, each on creek lines in remnant vegetation where dams had been constructed. This species also was recorded in a gutter by a track, that was not far from a creek line. *Pseudophryne semimarmorata* was recorded at only two sites, both in the same channel about one km apart. During the survey no other frogs were heard at these sites, which contained little or no water for most of the survey year.

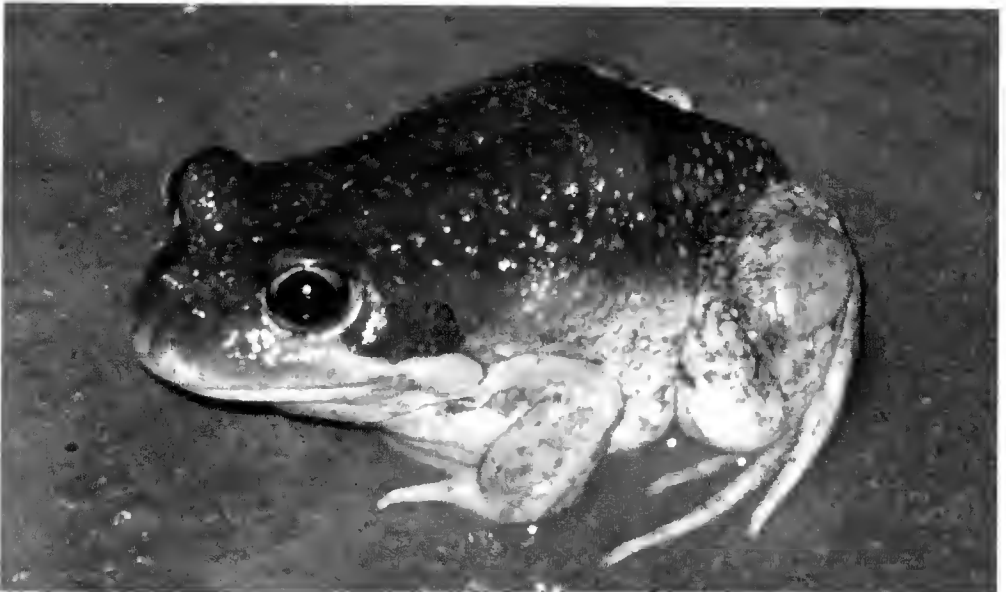


Fig. 2. Eastern Pobblebonk *Limnodynastes dumerilii*. Photo by Robin Drury.



Fig. 3. Striped Marsh Frog *Limnodynastes peronii*. Photo by Robin Drury.

The spring/summer callers were *Limnodynastes dumerilii* (7 sites) (Fig.2), *Limnodynastes peronii* (1 site) (Fig. 3), *Limnodynastes tasmaniensis* (5 sites), *Litoria peronii* (3 sites) (Fig. 4) and *Litoria verreauxii verreauxii* (4 sites). Except for the Lysterfield Lake site, where it was not recorded, *Limnodynastes dumerilii* was recorded at all sites that contained reasonable water levels at some time during the spring/summer period. *Limnodynastes tasmaniensis* showed similar requirements to *Limnodynastes dumerilii*, but was not recorded at as many sites. *Litoria peronii* was recorded at sites where there were reasonable water levels during the survey and adjacent meadow or open canopy. *Litoria verreauxii* recordings showed a similar pattern to *Litoria peronii*, although it was also recorded at one canopied site. *Limnodynastes peronii* was recorded at only one site, a farm dam with adjacent meadow.

Churchill and Lysterfield Parks provide a range of wetland habitats that support nine species of frogs. All species with distributions in the region (Frogs of Australia website) are

represented, except *Litoria raniformis* and possibly *Neobatrachus sudelli*. Two of the species, *G. victoriana* and *P. semimarmorata*, were 'lesser recorded' species in the Melbourne Water frog census 2007-2008 (Ecology Partners 2008). *Pseudophryne semimarmorata*, which has state significance (Ecology Partners 2008), is also listed as vulnerable in the Department of Sustainability and Environment 2007 list (DSE 2007).

The study occurred in an extended drought period in Victoria, with the summer period being particularly dry. Rainfall records from the nearby Horticultural Research Institute in Knoxfield show that the area received only 72% of its long-term average during the study period and only 52% of the summer average. In January and February only 8.5% of their long-term average rainfall was recorded. Water levels were much reduced at most sites after the December 2008 survey and remained so until the end of the study period, in May 2009. The two surveys carried out in late summer/early autumn found call activity at only four and three sites respectively.

Rainfall has been shown to have a primary impact on frog breeding likelihood, irrespective of other seasonal conditions (Littlejohn *et al.* 1993). The availability of water (Ficetola and De Bernardi 2004) and the hydroperiod, or the length of time a wetland retains water, have also been shown to be important determinants of frog activity (Snodgrass *et al.* 2000). Martin (1969) found that soil moisture was also a key determinant in the emergence of burrowing frogs *Limnodynastes dumerilii*.

The lack of rain can lead to an underestimate of the frog species that might use a particular site, especially where one relies only on advertisement calls. This became even more apparent when we carried out a follow-up survey of some of the sites in late November 2009, after 109 mm of rain had fallen in the previous 10 days. All sites had more water than previously seen. On this occasion, six of the species were recorded at sites where previously they had not been heard. *Limnodynastes dumerilii* was recorded at an additional five sites.

Acknowledgements

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Fig. 4. Peron's Tree Frog *Litoria peronii*. Photo by Robin Drury.

A fungus, a gnat and an orchid — the Helmet Orchid's strategy of deception



Fig. 1. Fringed Helmet Orchid *Corybas fimbriatus*. Photo by Pat Grey.

Cam Beardsell, Parks Victoria Ranger and orchidologist, observed the game of deception played each winter by Helmet Orchids in the eastern Conservation Zone of the Yarra Valley Parks. Out Warrandyte way, in the Red Box woodland, there exists a curious *ménage à trois* between a fungus, a fungus gnat and an orchid (or several). All grow together on the river terraces in moist, shady areas.

The fungus is *Dermocybe clelandii* (previously *Cortinarius subcinnamomeus*, identified by JH Willis, pers. comm. 1983)(see front cover). It has a dark brown cap (diameter to 65 mm) with a pale margin, mustard-yellow gills, which become rusty-brown with maturing spores, and a yellowish-brown, fibrous stem (length to 75 mm). The cobwebby veil (cortina) covering the young gills is a pale yellow. The dry cap and stem place it in the *Dermocybe* group of the *Cortinarius* family.

Fungus Gnats (*Mycomya* sp.) belong to the family Mycetophilidae. They are small, mosquito-like flies with a characteristic humped thorax and long slender legs. The larvae are long and worm-like with soft whitish bodies. Female Fungus Gnats normally lay their eggs under the cap of *Dermocybe clelandii*, in amongst the gills. When the larvae hatch, they eat their way through the mushroom cap, then drop to the ground to pupate.

However, in her search for an egg-laying site, the female Fungus Gnat is tricked into pollinating several species of Helmet Orchid (Genus *Corybas*) (Fig. 1). Helmet Orchids grow near

the ground and have one green leaf and a maroon flower. The Helmet Orchid mimics the shape and scent of *Dermocybe clelandii*, and so tricks the female gnat, which enters underneath the 'helmet' in search of a site to lay her eggs. Instead, she is dusted with pollen before realising her mistake and moving on. The Fungus Gnat needs to be tricked twice for the strategy to work so she must visit a second helmet orchid to deposit the pollen.

But that is not the end of the story; in contrast, the male Fungus Gnat is tricked into pollinating species of Gnat Orchids *Acianthus* spp. and Greenhoods *Pterostylis* spp. The attraction here is sexual: the pheromones emitted, and the shape of the orchid labellum mimic female Fungus Gnats. The male gnat tries to 'mate' with the orchid. Instead, it picks up pollen which is then carried to other Gnat Orchids or Greenhoods for their pollination. In Greenhoods, when the male Fungus Gnat, its dorsal side towards the flower, tries to copulate with the labellum, it triggers the labellum to spring back and trap the insect with its front end towards the top of the hood and against the column. This is where the stigma and anthers with the pollinia are positioned and pollen is deposited on the gnat.

This relationship holds an evolutionary puzzle. The Fungus Gnat family is Gondwanan, and must date back before the break up of the ancient southern super-continent about 50 million years ago. On the other hand, the ancestors of the Helmet Orchid are much later colonisers of Australia, entering when the Australian

tectonic plate neared the islands to the north about 20 million years ago. Some Helmet Orchid relatives are epiphytes on the branches of tropical trees. How did our Helmet Orchids' exploitation of the Fungus Gnat evolve?

This is just one example of how very complex ecosystems are. The threat to these and many other native orchids is obvious. If their pollinators are wiped out, the orchids are doomed. In this case, the Helmet Orchids, Gnat Orchids and Greenhoods depend on the survival of the Fungus Gnat, which depends on the survival of the mushroom, *Dermocybe clelandii*. In turn, this mushroom, by its mycorrhizal association, ensures the health of the eucalypts ... and so on.

Acknowledgements

Thanks to Cam Beardsell for this wonderful tale.

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Graham Patterson, Pat Grey and Ed Grey

PO Box 175, Lower Plenty, Victoria 3093

Springtail eats slime mould!

On 5 July 2009, the Fungi Group of the Field Naturalists Club of Victoria (FNCV) made a fascinating discovery while foraging on the Lerderderg Heritage River Trail from the Jack Cann Reserve, in the Wombat State Forest, near Blackwood, Victoria. (37°28'35.4"S 144°17'13.2"E; I can give the location with confidence because it was right next to a rare 'toothpick' fungus that we were recording and we took a GPS reading of that).

The trail passes through dry box and stringybark heathy woodland and on the side of the track we found a bright yellow slime mould (Myxomycete) on a patch of leafy liverwort. This was not especially unusual in itself, but I am interested in slime moulds and was keen to record it. The specimen was still transforming from the plasmodial stage, but the very weak strand-like stalks and pendant sporangia suggested it was *Badhamia* sp. However, while photographing the slime mould, I noticed that some of the sporangia had been disturbed and seemed to be reverting back to plasmodial slime— something they easily do when physically disturbed at this stage of their development. Upon closer inspection of my photos, I was surprised, and delighted, to see the cause of this disturbance—a tiny creature was feasting on the slime mould!

This stunningly beautiful little beastie (it was only about 3–4 mm long) (Fig. 1) had the most remarkable colours and features. It had a purple body with two rows of pink processes down each flank (the outer ones were quite long). I had never seen anything like it before, so I sent an image to Ian Endersby who suspected it was a type of springtail and forwarded it on to Penny Greenslade (a world-renowned expert on the taxonomy and ecology of Collembola). She confirmed that it was indeed a springtail—an ucid Collembola of the genus *Acanthanura* (subfamily Uchidanurinae). The species of this subfamily are the largest and most spectacular of the springtails, and unlike most springtails, lack a jumping organ. Greenslade co-authored an article in *The Victorian Naturalist* (Greenslade *et al.* 2002), describing log-inhabiting Uchidanurinae. The article recorded two observations of these creatures feeding on the plasmodial stage of slime moulds in Victoria and Tasmania, and suggested that this may be more common than previously thought. She suggested that their specialised mouthparts indicate that they have a preference for, or even feed exclusively on, slime moulds.

Penny was quite excited by this find and pointed out that these creatures are quite rare



Springtail on slime mould.

and endangered by fire and logging. Large parts of the area we visited were recently burnt, and the Wombat State Forest does have proposed logging coupes (although not in the area around the Heritage Walk where we were), so the threats may have been quite close for these particular individuals. The weather was cold, overcast and tending to drizzle—ideal conditions for uchid springtails (and many slime moulds), which like low temperatures and high humidity.

The FNCV Fungi Group often finds springtails amongst the gills of fungi. Penny has found that some endemic species and even genera of Collembola specialise on fungi, and some feed exclusively on the fungal spores.

The ecology of fungi, slime moulds and insects is fascinating. Stephenson and Stempen (2000) describe beetles that are commonly found feeding on the sporangia or plasmodium of slime moulds and suggests that some are obligate myxomycete specialists. Certain species of flies are also known to lay eggs in slime mould plasmodium and the larvae feed on the plasmodium. There are also a number of fungi

that colonise slime moulds. Myxomycetes typically feed on bacteria found in decaying wood and litter; however, there is evidence that some slime moulds prefer growing amongst mosses and liverworts — presumably these provide a suitable habitat for sporulation. Some slime moulds also are known to feed on fungal spores.

Unfortunately, I did not collect the Collembola (it didn't occur to me to do so at the time, and I wouldn't have known how to handle it anyway). I did collect the slime mould but the animal appeared to have fled pretty quickly (although it seemed

unperturbed by people taking photographs for about 15 minutes).

To be honest, I was glad it departed, because I did not want it to eat all the slime mould before I had a chance to examine it. As it happened, much of the slime mould disintegrated on the journey home.

I believe the slime mould was *Badhamia* sp., but my microscopical examination was constrained by the very few sporangia that had matured. It had dark brown, warty spores, mean size 12.1 by 11.0 μm , with large limey plates (capillitia were not observed).

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Paul George
238 Canterbury Road
Canterbury, Victoria 3126

Discovery of a large population of Rye Beetle Grass *Tripogon loliiformis* on the volcanic plains west of Melbourne, with observations on ecology and propagation

Rye Beetle Grass *Tripogon loliiformis* (F. Muell) C.E.Hubb is a tiny, warm season grass that commonly grows to only 4 cm high, with a flowering culm to 15 cm. Current records in Victoria suggest that the species is scattered and rare throughout dry, rocky areas of the state including on the basalt plains just west of Melbourne and on sedimentary formations at Mt Arapiles, the Strathbogie Ranges, Wangaratta and Suggan Buggan (Walsh and Entwistle 1992). The species also grows on shallow granite soils at Terrick Terrick National Park (pers. obs.). The species occurs in all mainland states of Australia. Rye Beetle Grass is one of few 'resurrection' plants indigenous to Victoria which has the ability to rehydrate its foliage rapidly following sufficient rain.

Ecology

On the basalt plains west of Melbourne, Rye Beetle Grass is restricted largely to shallow (<7 cm) soil platforms overlying basalt rocks. These sites have a relatively open vegetation cover, as larger plant species appear unable to grow on the shallow, rocky soils. The platforms are occupied only by species whose life strategies allow them to cope with the harsh habitat conditions, and includes a range of mosses (which are able to dry and rehydrate in response to wetting and drying cycles) and annual herbs (which grow and seed in response to rain and die off as hotter conditions return). Rye Beetle Grass has evolved to grow in these conditions by adapting a life cycle that is very much akin to that of a bryophyte. Following dry conditions the leaves may shrivel and become inactive, but within days of rain they rehydrate and turn green.

The species' response to fire is largely unknown. The open cover and lack of vegetation cover characteristic of the species' habitat is likely to minimise fire intensity around plants. However, Bainbridge (unpublished data) noted that grass slash left around plants prior to a burn is likely to pose a threat by increasing fire intensity. A spring burn undertaken at the

Mt Ridley Grasslands appeared to have no detrimental effect on a Rye Beetle Grass population, whilst the species was found to be present in high numbers at Pioneer Park in Sydenham where several recent burns had been conducted (pers. obs.). The species is unlikely to be out-competed by over-growth of *Themeda* tussocks due to its specialised habitat niche. Stock grazing appears to have a negative effect on Rye Beetle Grass patches, as the shallow soils are easily compacted and plants tend to be trampled.

Discovery of a large population

On 28 October 2008, staff members of Applied Botany and Zoology Ecological Consulting (ABZECO) visited a large parcel of land in Deer Park, west of Melbourne, to undertake salvage of significant flora species. This land parcel, although supporting a high diversity of Victorian and Australian threatened flora, fauna and vegetation communities (including Striped Legless Lizard, Spiny Rice Flower and Small Scurf-pea), had been approved to be destroyed and developed for residential and industrial purposes. Most of the site had never been cultivated but had been grazed by stock for many years (Richard Francis pers. comm. October 2008).

Previous assessments had located one patch of Rye Beetle Grass within the site. On inspection of the site by ABZECO staff, it was discovered that an unusually large population was present. Such large quantities were discovered that several more site visits had to be organised to salvage the majority of plants. Approximately 1500 plants of Rye Beetle Grass, scattered across at least three ha of grassland, were located.

The quantity of Rye Beetle Grass recorded at Deer Park is possibly one of the highest population densities recorded in Greater Melbourne (Fig. 1). During flora surveys (undertaken by the authors) of large areas of plains grassland west of Melbourne in 2007/08, the species was recorded from at least eight sites. Most populations averaged fewer than 200 plants, and many populations were restricted to fewer than 20 plants.



Fig. 1. Close up of Rye Beetle Grass *Tripogon loliiformis* in seed.



Fig. 2. A colony of Rye Beetle Grass *Tripogon loliiformis*.

Propagation

The salvaged plants from Deer Park were kept at the ABZECO nursery or distributed to Friends groups to allow reintroduction to suitable sites. The plants were potted into shallow trays, some with moss species and some without. The plants were kept in relatively dry conditions with occasional heavy watering, in an attempt to mimic the conditions of their natural habitat. In November 2009, it was noticed that seedlings of Rye Beetle Grass had germinated in some of the trays (Fig. 2). Interestingly, plants had germinated only around moss beds. To the best of our knowledge, this is the first time that Rye Beetle Grass has been propagated in nursery conditions.

Conclusions

Rye Beetle Grass is under threat from land development, rock removal, stock grazing and

other threatening processes. The main distribution of the species in Victoria lies within the urban growth boundary and the species is threatened by land development. Consultants should be wary when assessing rocky, basalt grasslands, as there is a high possibility that the species may be present. Advice should be sought on identification to ensure that the species is not overlooked.

Acknowledgements

The authors would like to thank Richard Francis for supplying some of the ecology and recruitment information, and Jack Latti, Gareth Cook, Bradley Jenner, Jake Urlus and Katherine Whittaker for locating Rye Beetle Grass plants during the salvage operation.

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Karl Just¹ and Nicholas Evans²

¹Applied Botany, Zoology and Ecological Consulting (ABZECO) 1/4 Brisbane Street, Eltham Victoria 3095

²Plant Ecology Research Unit, Deakin University
221 Burwood Highway, Burwood Victoria 3125



Fig. 3. Rye Beetle Grass *Tripogon loliiformis* forming the lower layer in a structurally interesting grassland near Alice Springs.

Cronin's Key Guide: Australian Reptiles and Frogs

by Leonard Cronin

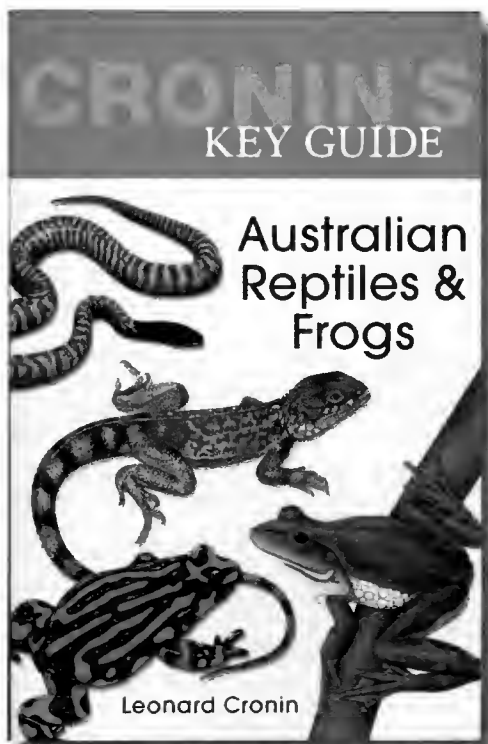
Publisher: *Allen & Unwin*, 2009. 232 pages, paperback.
ISBN 9781741751123. RRP \$35.00.

Herpetologists have long envied their ornithologist cousins for their comparative wealth of choice with regard to field guides. While the binocular-clad birdo struggles to choose between Simpson and Day, Pizzey and Knight, or Slater (and perhaps which khaki vest best compliments khaki cargo-pants), the herpetologist cuts a somber figure as he/she relentlessly tries to shove the latest version of Cogger into their backpack, squashing lunch in the process. Fortunately, this dichotomy of riches has eased somewhat in recent years, with the release of Wilson and Swan (2003) and a number of state and region-centric guides to reptiles and amphibians (Swan *et al.* 2004; Swan and Wathero 2005; Wilson 2005). One of the most recent contributions is *Cronin's Key Guide: Australian Reptiles and Frogs*.

This book is one in a series of field guides written by naturalist Leonard Cronin, covering Australian mammals, trees, wildflowers and rainforest plants. These guides are intended for a general audience, and as such do not constitute an exhaustive inventory of Australian fauna and flora, but rather focus on commonly encountered or particularly interesting species. A brief introduction includes general information about the herpetofauna of Australia, instructions on how to identify snakes and, importantly, information on how to apply first-aid to a snake bite. A very helpful illustrated index of species, complete with maps of geographic ranges, can be found on pages 11-25. This will be a particularly useful addition to amateur naturalists who can flick through illustrations of up to 15 species per-page, rather than thumbing through the entire guide trying to find that mystery skink or frog.

Although omitting species from a field guide is an obvious shortcoming, it allows Cronin to incorporate additional information on the approximately 200 species he does include. Rather than having multiple species per page as

in other guides (e.g. Wilson and Swan 2003), an entire page is dedicated to each species. The result is a generous amount of information detailing descriptions of the behaviour, physical appearance, development, diet and habitat of each species, all written in a simple and accessible manner. The section on behaviour will be of particular interest to many, as Cronin documents some of the more peculiar habits of our native herpetofauna, such as the devotedly monogamous lifestyle of the Shingleback Lizard *Tiliqua rugosa* or the way a Northern Death Adder *Acanthophis praelongus* lures its prey by wiggling its tail to mimic a worm or caterpillar.



This field-guide does have some shortcomings. First, because it is intended for a general audience, professional herpetologists may find it to have limited appeal. The plates are not of the standard of many bird and mammal guides (e.g. Menkhorst and Knight 2004), and the physical descriptions would help little if, for example, attempting to distinguish between closely related species of *Ctenotus*. I found the choice of species in the guide was generally in accordance with the aim of including those 'likely to be noticed in their habitats', with a couple of exceptions. For instance, the most commonly encountered species in the rich herpetofaunal assemblages of the Murray mallee region is the Mallee Dragon *Ctenophorus fordii*, but this species is not included in the guide.

Overall, I believe Cronin has made a solid contribution to the body of field guides of Australian reptiles and amphibians. This guide provides a good introduction to the herpetofauna

of Australia, particularly for individuals with an amateur interest in reptiles and amphibians. Additionally, the generous text on the species included constitutes a useful review of their ecology, and perhaps a good read for that eccentric breed of herpetologist who regards field guides as suitable (or ideal) bed-time reading.

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Dale G Nimmo

Landscape Ecology Research Group
 School of Life and Environmental Studies
 Deakin University, Burwood, Victoria 3125

One hundred and one years ago

EXCURSION TO BEVERIDGE

BY F.G.A. Barnard

This excursion took place on Saturday, 13th March, and was arranged for the purpose of visiting the extinct crater marked on maps of Victoria as Mount Bland, but locally known as Mount Fraser, after some previous owner of the property. Though the afternoon threatened to be showery, and the locality is generally considered an uninteresting one, the leader was pleased to have a following of 17 members and friends, including several ladies. Mt. Bland, or Beveridge Hill, as it is also known, can be easily seen on the northern horizon from the more elevated parts of Melbourne, such as the higher parts of Carlton, and from there lies a little to the west of due north. Beveridge station is 989 feet above sea-level, and as the mount is little more than half a mile from the station, the gradual slope towards the summit commences almost at once. The outlook here was extremely interesting. Fifty feet below was the floor of the crater, a perfectly level, little, plain, about 180 yards in diameter, while all round, in almost a perfect circle rose the encircling rim, except towards the north west, where it was broken down, and had formed the exit for the lava of former ages. On the southern side of the breach the rim rose to 1,280 feet, while on the opposite side (the northern side of the crater), it rose to its highest point, 1,380 feet above sea-level; round to the east it gradually fell to the spot from which we first viewed it. The breach itself is about 20 feet above the level of the floor. In one corner of the bottom is a waterhole for stock, excavated in the solid lava (bluestone), but, owing to the dry season, it contained little water. It is probable that in this isolated pond some interesting life might be found after a wet season. From the highest part of the rim an excellent view of the surrounding country was obtained. Though very hazy and stormy towards the south, we were able to pick out the You Yangs, 50 miles away; the Anakies, a little further; Macedon, Hanging Rock (the scene of the excursion three weeks before), 20 miles to the north-west. Due north was the Big Hill, or Pretty Sally's Hill, an outlier of the Dividing Range, with Wallan at its foot, while to the east were the Plenty Ranges, almost enshrouded in heavy masses of black clouds. Besides these more prominent mountains, numerous points of eruption occur all round, such as the Bald Hill, a little further south, Green Hill, close to Wallan, &c, details of which will be found in a paper by Mr. T. S. Hart, M.A., read before this Club some years ago (*Vict. Nat.*, xi., 74). Having taken in the surroundings sufficiently, we traversed the rim towards the west, to where, owing to the operations of rabbits, there was an exposure of tuffs and lapilli, of which nice specimens were secured.

From *The Victorian Naturalist* XXVI pp. 4-6 May 1909

Field guide to the frogs of Australia

by MJ Tyler and F Knight

Publisher: CSIRO Publishing, 2009. 200 pages, paperback; colour illustrations.
ISBN 9780643092440. RRP \$49.95

It's fair to say that amphibians are not faring too well at the moment. When compared with other taxa, a larger proportion of amphibians are considered at risk of extinction, with nearly a third of species categorised as 'globally threatened' (Stuart *et al.* 2004). The combination of numerous, often interacting factors, such as habitat fragmentation and loss, introduced species, climate shifts, and infectious disease, has led some workers to argue that we may be witnessing a 'mass extinction' of amphibians (Wake and Vrendenburg 2008). Even within our own backyard, some of our most familiar species, such as the Eastern Banjo Frog *Limnodynastes dumerilii* and the Southern Toadlet *Crinia signifera*, have experienced substantial declines over the past few decades (Mac Nally *et al.* 2009).

The first step towards conservation involves knowing your subject. Owing to a paucity of thorough field guides, even the seemingly straightforward task of species identification has been relatively complicated for herpetologists. However, respite is upon us with the release of Tyler and Knight's (2009) *Field Guide to the Frogs of Australia*.

This field guide has two distinct advantages over most frog guides: (1) it is comprehensive, including all 227 known frog species, and (2) it has illustrated plates rather than photographs, the latter being the norm in the vast majority of previous frog guides. Since the last comprehensive guide was published (Barker *et al.* 1995), over 20 new species have been described, highlighting the need for a revised version. Despite the new additions, the authors suggest that the taxonomy of Australian frogs remains far from complete, with perhaps another 15 species likely.

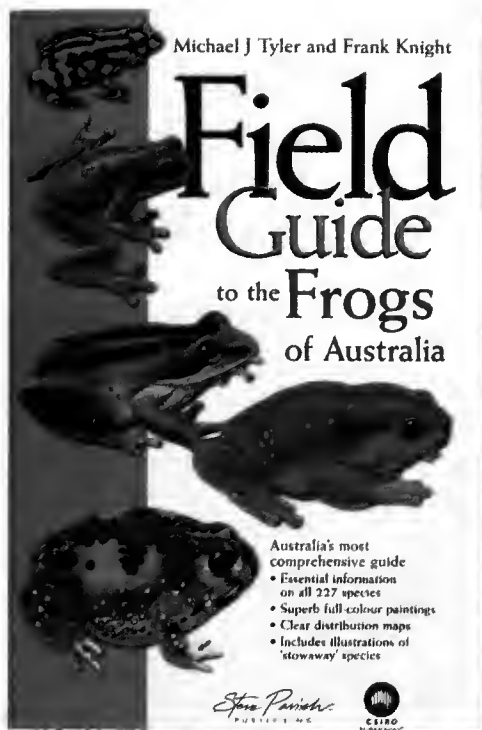
The introductory material includes the basics of frog biology, with a particular emphasis on anatomy, as well as some useful information on morphological differences between male and

female frogs. A short section on the six families of Australian frogs gives a good, albeit brief, summary of their morphology, history and distribution, including genera-specific information. A section on frog habitats will be particularly interesting to newcomers, as it highlights the remarkable diversity of areas that Australian frogs are able to inhabit, from swamps to arid shrublands.

The organisation of species accounts may come as a surprise to some herpetologists, many of whom will be accustomed to the alphabetical ordering of species in other Australian frog guides. Tyler and Knight have used an approach more familiar to ornithologists, by positioning morphologically similar species adjacent to each other, with alphabetic order being a secondary consideration. Although this makes locating species a little more time-consuming, it allows for a less complicated and more direct comparison of the morphological features that distinguish physically similar species.

Those familiar with Frank Knight's artistry (e.g. Menkhorst and Knight 2004; Pizzey and Knight 2007) won't be surprised that the plates are of high quality, with closely related species shown in a similar pose throughout. Both male and female morphs of species are shown where necessary, while for highly variable species, such as the Australian Lace-Lid *Nyctimystes dayi*, several morphs are presented. An oblique view of individuals (with the exception of a group of small *Litoria* species which are presented laterally) is sometimes complemented by a dorsal or ventral view, depending on their relevance to identification.

The short text on each species includes details on (where required): the snout to vent length of both males and females of the species; additional common names; details on different morphs; conservation status; distribution; habitat associations; advertisement calls; and similar species. Finally, a section on behaviour



provides details on (variously): characteristics of the spawn of species; time of year breeding occurs; and the habitats where breeding usually occurs. Other helpful aspects of this field guide include a glossary, a good reference list and, for those with an interest in developing a 'frog list', a checklist of genera and species.

Because no book review is complete without a little negativity, I did notice a couple of small errors here and there. For example, in the summary of the *Neobatrachus* genus it states that

the genus 'is confined to the southern portion of the continent'. However, if you flick to page 90 you'll see the Northern Burrowing Frog *Neobatrachus aquilonius* occurs in the Northern Territory and parts of northern Western Australia. However, such oversights are rare and minor.

Overall, Tyler and Knight have created a thorough and accessible guide, with a good balance between content and brevity. Australian herpetologists and frog enthusiasts finally have a field guide comparable to Australian bird and mammal guides. I anticipate this guide becoming a common acquisition by people interested in the biology and conservation of frogs, throughout Australia.

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Dale G Nimmo

Landscape Ecology Research Group
School of Life and Environmental Science
Deakin University, Burwood, Victoria 3125.

One hundred years ago

WILSON'S PROMONTORY NATIONAL PARK. — The committee of management desires to obtain living native animals and birds for introduction into the National Park. Kangaroos, rock wallabies, and wombats, with the smaller marsupials, such as flying opossums, rat kangaroos, bandicoots, and pouched mice, are particularly desired. Among birds, emus, lyre-birds, bowerbirds, mallee-hens, &c, are desired. Further particulars can be obtained from the secretary of the park, Mr. J. A. Kershaw, National Museum, Melbourne.

From *The Victorian Naturalist* XXVII, p. 35, June 9, 1910

The Place for a Village: how nature has shaped the city of Melbourne

by Gary Presland

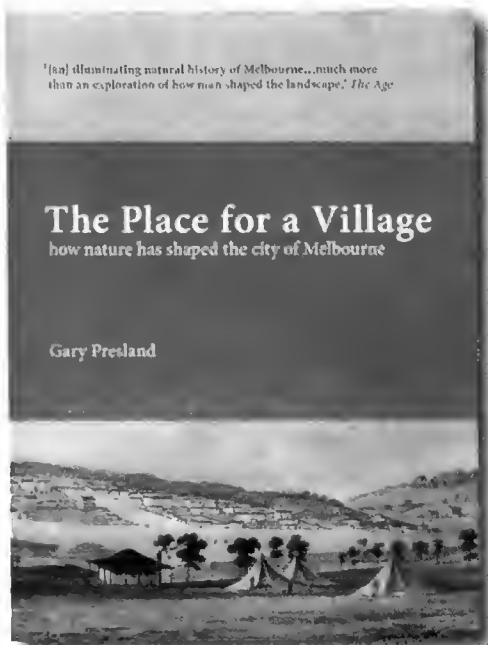
Publisher: *Museum Victoria, Melbourne, 2009. 2nd edn, 265 pages, paperback, colour illustrations. ISBN 9780980619027 RRP \$39.95*

Gary Presland's book aims to reconstruct the natural history of the Melbourne area as it was at the time of the arrival of the first Europeans. From those lost landscapes and ecosystems it should be possible to deduce how the physical development of Melbourne and its suburbs was influenced. It should also allow an interpretation of aboriginal life at the time.

The thesis of the book can be seen as a series of equations: underlying geology leads to topography and soils; topography plus climate influences hydrology; topography (including aspect) plus soils and climate influence vegetation; vegetation (as food and shelter) plus climate (seasonality) determines the fauna. This ecological model is further complicated by climate gradients and feedback loops such as that of plants and animals affecting the formation of soils.

Melbourne's landscape contains four physiographic units: the Nillumbik terrain of Silurian sediments, volcanic flows, Tertiary sandstones, and Quaternary alluvial deposits. Geological processes working on these formations give rise to the topography as we know it. The Dandenong ranges are outside of the study area but have a strong influence on climate and waterways. The geological features of the ledge of basalt which separated fresh water from salt near where Queens Street crosses the Yarra, and the basalt plains to the west of the city with their luxuriant cover of native grasses, were instrumental in attracting European settlement to the site. Soil types and aspect have driven the way the city has spread.

While wind, rainfall, humidity and barometric pressure were recorded from the earliest times, the science of meteorology only arrived with George Neumayer in 1857. There is a strong rainfall gradient across Melbourne, almost doubling from the basalt plains in the west to the higher country in the east, and it is



rainfall that has had the greatest influence on Melbourne's shape.

Chapter 3 gives a masterly reconstruction of streams and wetlands, tracing their routes which now may be in underground drains or diverted. Major alterations, particularly for the Yarra, are documented.

The original vegetation is reconstructed from historical information, remnant vegetation on-site, and regional vegetation associations. Extensive use is made of the Ecological Vegetation Class nomenclature. Original plant communities are deduced for the major topographic terrains: Silurian sediments, Tertiary sands, Basalt plains, Quaternary alluvium, wetlands and

coastal areas. Plant lists for some of these are given in appendices.

Finally, in Chapter 5, all of the components are brought together to describe the animal life with examples of mammals, birds, fishes, reptiles, amphibians, insects and spiders.

Now we have a reconstruction of the natural history of early Melbourne based on its abiotic and biotic ecological components and their myriad interactions. Part 2 uses this background to examine seven topics including the lifestyle of the aboriginal people, why the city is located where it is, modification of our rivers, and the way the shape of Melbourne has evolved.

So that is the thrust of the book. It is well produced with numerous relevant coloured plates of maps, scenes, vegetation and animals. It was

awarded the Community History Award for 2009, an accolade well deserved.

A couple of small criticisms: I would have found the large numbers easier to read if they had not lost their commas, and faint captions to pictures and quotations were almost illegible to my eyes. Typographical errors were present, but pleasingly few. I am a little suspicious of the record of Brush Turkey *Alectra lathamii* for the Merri Creek.

Buy or borrow a copy for its methodology and its conclusions; it is a valuable contribution to the sense of place for those living in Melbourne.

Ian Endersby
56 Looker Road
Montmorency, Victoria 3094

Invisible connections: why migrating shorebirds need the Yellow Sea

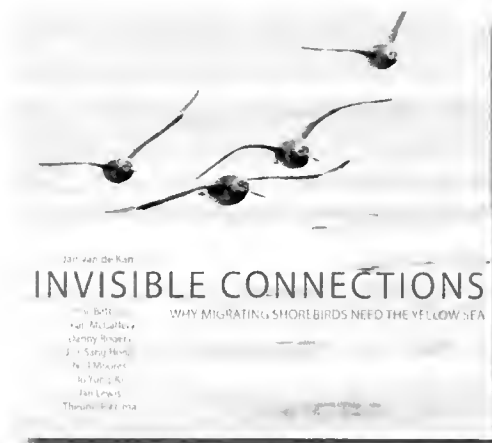
by J van de Kam (Photographs), P Battley, B McCaffery, D Rogers,
J-S Hong, N Moores, J Yung-Ki, J Lewis and T Piersma

*Publisher: CSIRO Publishing, Collingwood, 2010. 160 pages, paperback;
colour photographs. ISBN 9780643096592. RRP \$49.95*

This book has been inspired by the awesome feat of shorebird migration, and by a deepening concern over the loss of key migratory stopover sites. It is the product of a passionate group of world renowned scientists and a world renowned photographer, who have dedicated large portions of their professional lives to documenting the wonder and demise of the Yellow Sea, perhaps the most important link in the migratory pathway used by shorebirds, known as the East Asian-Australasian Flyway. This book represents a major achievement in diplomacy and collaboration (forewords from Australia, China and South Korea), and seems clearly targeted at the general public, presumably to inspire, educate and empower. Key among the threats to shorebird sites in the Yellow Sea is reclamation, an ancient practice which has reached an incredible and worrying scale, and which threatens a number of species and populations of migratory shorebirds. The

authors warn us that time is running out to save migratory shorebirds using the Yellow Sea, and they describe the gradual raising of awareness among the peoples of the Flyway to the story of migration and the value of the 'invisible connections' they provide.

Eight chapters describe the life history of migratory shorebirds, the habitats they use, the need for conservation action and some of the initiatives that have been invoked to help save these birds. The content is as international as the birds it describes, ranging from the arid coasts of Australia to the arctic tundras. Books such as this, written by a group of concerned scientists and conservationists, could fall into the trap of zealous advocacy in which the truth is melded to serve the desired outcome; however, the authors have kept it on solid scientific ground. Cutting edge research is presented and contextualised in a reader-friendly manner that is highly accessible to the average reader. It is



simply a delight to read the work of this star-studded cast of international shorebird biologists and ecologists.

This book is a feast for the eyes, with 240 wonderful colour photographs from throughout the Flyway (they are to be found on *every* page). These images are as good as photographs get, and they are reproduced and laid-out superbly. Page numbers are frequently (and rightly) omitted to leave the images unspoilt, and many images cover the entire page. The reader is treated not only to the customary spectacular close ups of individual birds (e.g. the Bar-tailed Godwit

on page 13), but also to behavioural sequences (e.g. the fight of two Whimbrel on page 122), and landscapes (e.g. the Great Knot standing vigil over the tundra valley in eastern Siberia on page 70). This is the most impressive collection of published shorebird images of which I am aware.

A few minor criticisms are possible for any book, and here they barely warrant mention. I would have liked to see a clearer distinction, for the lay reader, between migrants and residents (the latter also depend heavily on sites used by migrants) and the caption on page 92 is not strictly accurate with respect to Point Cook. However, these issues are trivial.

I cannot overstate my enthusiasm for this book, and it is not just because I am a shore-birder! This book is about birds, but also about people and places, and the precious things we are set to lose if we don't become more sympathetic to the needs of the wildlife with which we share the planet. The contributors are to be congratulated, not only on the quality of their work, but also on taking the initiative to take their science to a broad audience. I highly recommend this wonderful book.

Michael Weston

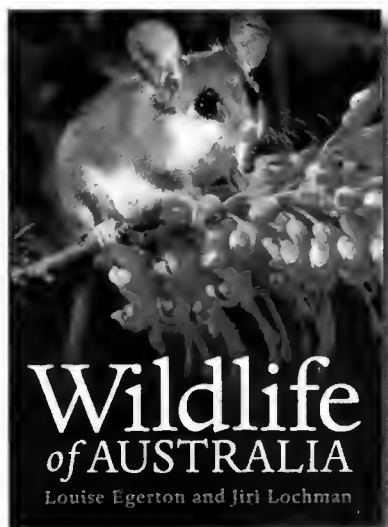
School of Life and Environmental Sciences
Deakin University, 221 Burwood Hwy
Burwood, Victoria 3125

Wildlife of Australia

by Louise Egerton and Jiri Lochman

Publisher: Jacana Books, 2009, 448 pages,
hardback, colour photographs.
ISBN 9781741149975. RRP \$59.99

What can I say about this book? *Wildlife of Australia* contains a wealth of information on Australian biodiversity, with separate sections devoted to mammals, birds, freshwater fishes, reptiles, frogs and invertebrate species. Selected species appear in family groupings and the habits, habitat, breeding and feeding of each are discussed.



There are many interesting facts to be learned from this book, and extra little tidbits are presented in boxes separate from the rest of the text.

While the description of each species contains much factual, informative and interesting detail, I found the attempts at humour and the anthropomorphic writing style, used by the author particularly for the mammals, but also employed throughout the book, to be extremely irritating.

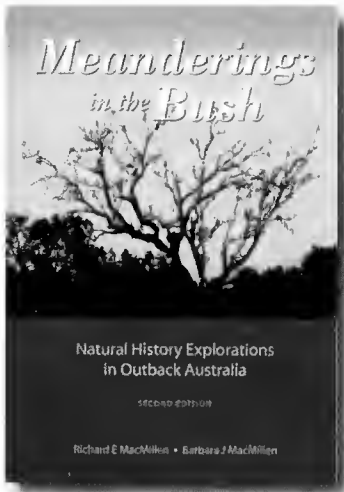
I did learn information of which I was not previously aware, but still had difficulty deciding to

whom the book was directed. Was it for children? Or perhaps it was written for the overseas market, as every measurement was in metric with imperial measurements in brackets.

The photographs were grand as one would expect from the hands of Jiri Lochman and the other contributors, with super photos appearing in all sections of the book.

Anne Morton

10 Rupicola Crt
Rowville, Victoria 3178



Meanderings in the Bush: Natural History Explorations in Outback Australia

by Richard E MacMillen and
Barbara J MacMillen

Publisher: CSIRO Publishing, Collingwood, 2009. 2nd edn, paperback, 208 pages. ISBN 9780643097063. RRP \$49.95.

This book is a record of American ecologist Richard MacMillen's six visits to Australia over a period of 26 years. As well as descriptions of field work conducted, mostly in Queensland's Channel Country, there are stories of other meanderings in the outback and of living on an island in the Hawkesbury River.

MacMillen's field work was wide-ranging and included: small mammals such as Kowari, Kultarr and Fawn-hopping Mice; Inland Crabs and their burrowing strategies to survive the dry times; and parrots such as Red-rumped, Ring-neck and Little Corellas with their economical use of water.

In addition to field work, there were meanderings, travels and explorations around the coun-

try. The stories of many adventures and some misadventures are told in a humorous style, all the while showing respect for the country, the station people and outback characters and the fauna encountered and studied.

In Chapter 7, MacMillen discusses the adaptations to the arid environment adopted by some of the wildlife. Chapter 8 introduces the human dimension into the equation and questions whether the native creatures can survive under the changes brought about by the human occupation and use of the outback areas. MacMillen suggests solutions for co-existence; recent history would suggest that it is unlikely that governments will listen.

As an ecologist and as a traveller to many of the places mentioned, I enjoyed reading this book. Now I am looking forward to going back again to see it with fresh eyes.

Anne Morton

10 Rupicola Crt
Rowville, Victoria 3178

Cronin's Key Guide: Australian Rainforest Plants

by Leonard Cronin

Publisher: Allen & Unwin. 2009, 181 pages. ISBN 9781741751130. RRP \$35.00

This is Cronin's sixth in a series of natural history books and features more than 300 common rainforest species of Australia. Cronin writes: "This book is designed as a simple, easy-to-use field guide and an introduction to some of the major and most commonly admired rainforest flora. It is a wonderful little book that leads the reader along the road to awareness and appreciation of the great diversity of Australia's rainforest plants.

The book begins with a brief introduction that describes rainforest characteristics and identifies the broad rainforest types before concluding with a section that details how to use the guide.

Plants are arranged according to type, i.e. Trees, Palms, Pandans, Cycads, Banana, Tree Ferns, Ferns, Vines and Wildflowers. Within

each plant type, species are presented within their families, two to a page. Family, species name and size head each species contribution. A common name in larger font is provided below this header followed by a description of the plant, detail of its bark (where appropriate), leaves, flowers and fruits or cones for gymnosperms and sporangia for ferns. The information for each plant finishes with a brief account of its habitat. Information provided for each species is informative, useful and sufficiently detailed for confident identification. A distribution map and colour illustration also is provided for each species. The colour illustrations are accurate and sufficiently detailed to further provide the reader with confidence in their identification, and the illustrators are to be commended.

The text avoids cumbersome scientific language but some terminology is unavoidable; however, a small but sufficient glossary is provided and includes a pictorial glossary of leaf shapes, flower parts, flower arrangements and leaf arrangements. These are invaluable. The index is useful and provides both scientific and common names.

The book is particularly ideal for the traveler interested in identifying some of Australia's rainforest plants. It is conveniently sized, well presented, written and illustrated, and is well worth its cost of \$35.00.

Maria Gibson

Plant Ecology Research Unit
School of Life and Environmental Sciences
Deakin University, Burwood, Victoria 3125



The Fungi CD: 2nd Edition 2009

Publisher: *Field Naturalists Club of Victoria*, 2009. RRP \$15.00

Over 1100 high quality images, along with detailed descriptions of 250 species of fungi, are featured on the 2nd edition of *The Fungi CD*, published under the auspices of the Field Naturalists Club of Victoria Fungi Group.

A clearly written introductory section includes basic information about biodiversity, the interconnectedness of all living things, the importance of fungi to our everyday lives and their vital ecological roles as decomposers, parasites and symbiotic partners with plants. There is a section about slime moulds with a summary of a talk by Paul George.

For those baffled by the ever-changing names of fungi, there is a brief overview of the Linnaean system of classification and the work of Elias Fries (1794–1878) who used morphology and spore colour to classify fungi. Recent research, especially DNA analysis, is changing our understanding of the genetic relationships between different species of fungi and leading to much taxonomic debate.

The 'fungi skills' section advises on making fungi collections, obtaining spore prints and photographing fungi. An illustrated glossary defines commonly used terms.

There are several ways of finding a name for the species included on the CD. Gilled or non-gilled fungi can be searched for by shape, genus or species. The 'shape' page has a button for selection by spore colour. Each species is illustrated with up to five photographs, showing different stages of growth and variations in colour, with a short paragraph describing basic field characters. A separate section (accessed by clicking on the name of the species) gives detailed descriptions of biology, including life mode and growth habits; size, shape and colour of the pileus (cap), lamellae (gills) and stipe (stem); general comments, and a description of microscopic features. A full list of references is included in this section.



Congratulations to all members of the Victorian Fungi Group and particularly Jurrie Hubregtse who took most of the photographs and compiled this informative fungal resource. Further images are of the excellent quality you would expect from such accomplished photographers as Arthur Carew, Paul George, Virgil Hubregtse, Ed Grey, Ivan Margitta, and Geoff Lay.

The CD can be used on PCs, Macs, and Linux computers. It needs a screen size of 1024 x 768 pixels so some scrolling is required if the CD is used on a small laptop.

Given the sheer number of fungal species, many of which are yet to be described, it was unrealistic of me to expect that this new fungal resource would help to identify scores of my unnamed photographs. However, it did enable me to identify several species and update other names. It is an excellent guide; I highly recommend it and eagerly await the next edition.

Sarah Lloyd

999 Denmans Road, Birralee, Tasmania 7303
Email: sarahlloyd@iprimus.com.au



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Postal Address: FNCV, Locked Bag 3, Blackburn, Victoria 3130, Australia.

Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.

email: admin@fncv.org.au

www.fncv.org.au

Patron: His Excellency, the Governor of Victoria

Address correspondence to:

The Editors, *The Victorian Naturalist*, Locked Bag 3, Blackburn, Victoria, Australia 3130.

Phone: (03) 9877 9860. Email: vicnat@fncv.org.au

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